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Auto-Batch concrete control system

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DEDICATION

Our parents, everything we are because of you. Thank you for all that you have done for us. We will never be able to repay you for the time and love you showed us growing up, but know that we love and appreciate it all, every single day. Thank you for the countless memories.

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Many thanks for our **lecturers** for all efforts to make us open minded engineers. Our **friends** and **colleges**, thank you for all beautiful and vital moment that gathered us, you are the best.

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NOMENCLATURE

PLC	Programmable Logic Controller
SCADA	Supervisory Control and Data Acquisition
HMI	Human Machine Interface
RMC	Ready-Mix Concrete
RTU	remote terminal unit
ERP	enterprise resource planning
ANN	Artificial Neural Network
GA	Genetic Algorithm
ANN-GA	Artificial neural networks for genetic algorithm
WinCC	Windows Control Center Open Architecture
DIA VIEW	Delta Industrial Analytics View
PID	Proportional-Integral-Derivative
DCS	Distributed Control System
MTBF	Mean Time Between Failures
ABB	Asea Brown Boveri (A Swiss-Swedish multinational company)

Abstract

The automation of concrete factories plays a pivotal role in augmenting efficiency, productivity, and product quality. This graduation project is oriented towards the development and execution of an integrated automation system aimed at overseeing and managing the operations of a concrete factory. The proposed system will encompass a wide array of concrete production facets, including material handling, batching, mixing, pouring, and curing. It will leverage cutting-edge technologies such as programmable logic controllers (PLCs), industrial sensors, and supervisory control and data acquisition (SCADA) software to ensure real-time monitoring and control of the production process. The project will tackle the challenges associated with integrating diverse components, ensuring data integrity, and implementing robust control algorithms. The successful deployment of the automation system is anticipated to yield substantial enhancements in production efficiency, operational cost reduction, and product quality enhancement, thereby contributing to the overall success of the concrete factory.

CONSTRAINS

Obstacles to the design of control and monitoring systems for ready-mix concrete factories:

Specific project:

1-Production capacity and productivity:

- The design is based on the required hourly/daily productivity of concrete.
- Consider variations in demand and peak production requirements.

2-Types of concrete and mix designs:

- The system must accommodate different types of concrete and their specific recipes.
- Adapt to modifications in mix designs based on material properties or customer needs.

3- Factory layout and equipment:

- Seamlessly integrate with existing machines and workflows.
- Consider physical limitations and potential expansion plans.

4-Technical limitations:

User interface and monitoring:

- Design intuitive and easy-to-use interfaces for operators and supervisors.
- Providing real-time data visualization and historical data analysis tools.

When choosing a Programmable Logic Controller (PLC) for designing a control and automation system for a concrete factory, especially when integrating with a control interface designed using DIAView and programming using Delta PLCs, several technical constraints should be considered:

1. Compatibility

- DIAView Integration: Ensure that the chosen PLC is fully compatible with the DIA View HMI/SCADA software. Delta PLCs are designed to work seamlessly with DIA View, so opting for a Delta PLC model would ensure compatibility.
- Communication Protocols: Verify the communication protocols supported by both the PLC and the DIAView program (e.g., Modbus, Ethernet/IP, CAN open, etc.).

2. Performance Requirements

- Processing Speed: The PLC should have a sufficient processing speed to handle the control logic and data processing needs of a concrete factory.
- I/O Response Time: The response time of the I/O modules should meet the real-time requirements of the automation system.

3. I/O Requirements

- Digital I/Os: Estimate the number of digital input and output points needed for sensors, actuators, and control devices.
- Analog I/Os: Calculate the number of analog inputs and outputs for devices like temperature sensors, pressure transducers, and flow meters.
- Expandable I/O Modules: Consider if the PLC supports expandable I/O modules for future scalability.

4. Environmental Conditions

- Temperature Range: The PLC should operate reliably within the temperature range typical of a concrete factory environment.
- Dust and Moisture Protection: Look for PLCs with appropriate IP ratings to protect against dust and moisture.

5. Power Supply

- Voltage Requirements: Ensure the PLC supports the power supply voltage available at the concrete factory.
- Power Consumption: Assess the power consumption to ensure it is within the limits of the power supply infrastructure.

6. Reliability and Durability

- MTBF (Mean Time Between Failures): Choose a PLC with a high MTBF for long-term reliability.
- Shock and Vibration Resistance: Consider the mechanical robustness of the PLC in environments with significant shock and vibration.

7. Networking and Communication

- Network Connectivity: Ensure the PLC has adequate networking capabilities (Ethernet, serial, etc.) for integration with other systems and remote monitoring.
- Communication Ports: Sufficient number and types of communication ports (e.g., RS-232, RS-485, USB, etc.).

8. Programming Capabilities

- Software Tools: Compatibility with the Delta PLC programming software, like ISPSoft.
- Programming Language Support: Ensure the PLC supports required programming languages (e.g., Ladder Logic, Structured Text).

9. Data Logging and Storage

- Memory Capacity: Adequate memory for data logging and program storage.
- Data Retention: Non-volatile memory for data retention in case of power loss.

10. Cost and Budget

- Initial Cost: Consider the purchase cost of the PLC and any additional modules or accessories.
- Maintenance Costs: Factor in potential maintenance costs over the PLC's operational life.

11. Vendor Support and Documentation

- Technical Support: Availability of technical support and after-sales service from the vendor.
- Documentation: Comprehensive documentation and user manuals for installation, programming, and troubleshooting.

12. Redundancy and Safety

- Redundancy Features: Availability of redundant power supplies, CPUs, and communication modules for high availability.
- Safety Certifications: Compliance with safety standards and certifications relevant to the concrete industry.

For a project involving the design of a control and automation system for a concrete factory using Delta PLCs and DIAView, it is crucial to select a PLC that aligns with the technical and environmental requirements of the application. Opting for Delta PLCs would ensure seamless integration and compatibility with DIAView and other Delta products, while also considering performance, I/O needs, environmental factors, and cost-effectiveness.

Chapter 1: Introduction

1.1 Overview:

The ready-mix concrete industry is one of the vital industries worldwide, given its essential role in construction and reconstruction projects. In Palestine, this industry is of great importance at present, as the country is witnessing a significant phase of activity in infrastructure and reconstruction, which enhances the demand for ready-mix concrete as a fundamental material in construction processes. This sector plays a significant role in supporting the local economy and providing direct and indirect job opportunities.[1]

Ready-mix concrete plants offer many advantages, such as ensuring the quality of the mix and precise control over its composition and strength, as well as contributing to reducing waste in construction processes. These plants can produce a variety of concrete suitable to meet different needs in various application areas.[2]

The concrete industry in Palestine has witnessed significant developments in recent years, leading to an increase in concrete production. This development is attributed to the growing demand for concrete, reflecting the country's economic growth and the rise in construction numbers.[2]

Figure 1: General appearance of the concrete plant

The modernization of concrete plants is an important part of this progress, leading to increased production efficiency and improved product quality. This development includes the use of more advanced equipment, adopting modern production techniques, and compliance with international quality standards. The table below shows the number of concrete plants in Palestine according to the 2017 statistics from the Palestinian Central Bureau of Statistics. [3]

Table 1: Number of ready-mix concrete manufacturing establishments in Palestine

Governorate symbol	Governorate name	Number of factories
1	*Jenin*	11
5	Tubas and the northern Jordan Valley	1
10	Tulkarm	6
15	Nablus	8
20	Qalqilya	5
25	Salfit	3
30	Ramallah and Al-Bireh	8
35	Jericho and the Jordan Valley	2
40	Jerusalem	6
45	Bethlehem	12
50	Hebron	16
55	North Gaza	5
60	Gaza	7
65	Dair Al Balah	8
70	Khan Younes	1
75	Rafah	10
The total		109

Concrete production in Palestine exceeded 2.5 million cubic meters in 2022, and continued growth is expected in the coming years. The future of the concrete industry in Palestine is expected to continue expanding, due to ongoing economic growth and increasing demand for housing and infrastructure development.[3]

Automation of production of concrete mix: Computer-aided design of concrete leads to a reduction in terms of production, the exclusion of product deficiencies, improve the quality of manufactured products. This approach allows to produce concrete to exact physical and mechanical characteristics, which makes the design more reliable and economical. The software package will allow: to reduce the settlement time in the design of concrete mixture, to improve the efficiency of the staff of the laboratory building, to improve the quality of the concrete mix due to higher accuracy of calculations, to apply a flexible approach to the design of concrete mixture in question of introducing new chemical additives and their characteristics. [4]

Some companies design a visualization and control system for their concrete batching plants, which consists of a SCADA/HMI system and PLC. the SCADA system allows, for example, the selection of plant types and models, the registration of vehicles and companies, and the generation of reports (inventory, production, distribution, sales), The Plant Configuration Wizard is available in SCADA for this purpose. SCADA is used to monitor control panel information, company, vehicle, driver, location, order entries, production plan creation, sales planning, dispatching, automated and manual production, among others, the data collected from the PLC (mixer motor, tool and coverage values) is transferred to the SCADA system using a server, and information from the plant configuration processor is sent to the PLC. The PLC automatically identifies and runs the work scenario based on this information. [5]

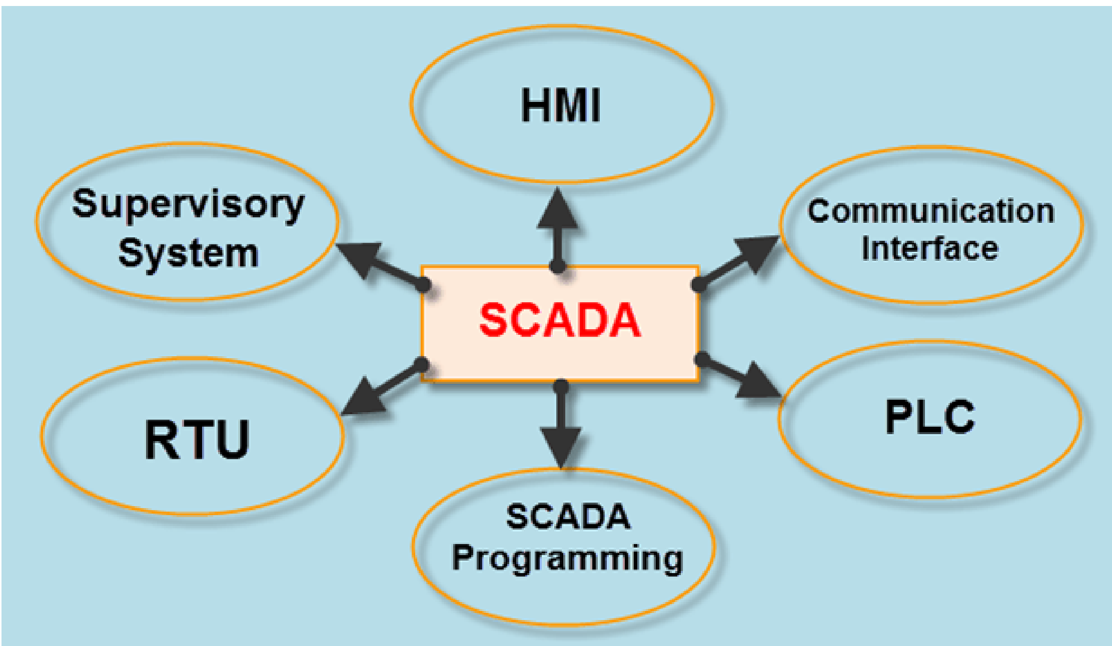


Figure 2: Basics of SCADA

1.2 Types concrete plants:

There are numerous classification standards for concrete plants. These include dry mix plants and wet mixing plants, which depend on the use of a central mixer. Additionally, they can be categorized as stationary concrete plants and mobile concrete plants, based on their mobility.

- **Dry mix concrete plant**

A dry mix concrete plant, also referred to as a transit mix plant, measures sand, gravel, and cement in weigh batchers using digital or manual scales. Subsequently, all the ingredients are discharged into a chute, which then feeds into a truck. Simultaneously, water is either weighed or metered volumetrically and discharged through the same charging chute into the mixer truck. These components are then mixed for a minimum of 70 to 100 revolutions during transportation to the jobsite.[6]

Figure 3:Dry mix concrete plant

- **Wet mix concrete plant**

In a wet mixed concrete plant, some or all the above ingredients (including water) are combined at a central location into a concrete mixer. The concrete is mixed at a single point and then agitated end route to the jobsite to prevent setting (using agitators or ready-mix trucks) or transported to the jobsite in an open-bodied dump truck. Dry mixed plants differ from wet mix plants in that wet mix plants contain a central mixer, which can provide a more consistent mixture in a shorter time (generally 5 minutes or less). Dry mix plants typically exhibit more break strength standard deviation and variation from load to load due to inconsistencies in mix times, truck blade and drum conditions, traffic conditions, etc. With a central mix plant, all loads undergo the same mixing action and there is an initial quality control point during discharge from the central mixer. Some plants combine both dry and wet characteristics for increased production or for seasonality. For instance, a mobile batch plant can be set up on a large job site. [6]

Figure 4:Wet mix concrete plant

The primary distinction between a wet and dry concrete plant lies in the mixing process. In a wet concrete plant, all the components are mixed in a large concrete mixer. In a dry concrete plant, the dry ingredients are first mixed, and then water is added on site. [6]

Here is a table illustrating some of the key differences between wet and dry concrete plants:

Table 2:differences between wet and dry concrete plants

The feature	Wet concrete plant	Dry concrete plant
Mixing method	Mix all ingredients together	Mix the dry ingredients first, then add the water
The quality	Higher quality	Lower quality
The cost	Higher cost	lower price or cheaper
Flexibility	Less flexible	More flexible
Applications	Applications that require high quality Such as bridges and tunnels	Applications that do not require high quality such as sidewalks and roads

The right choice of concrete plant depends on the project requirements. For high-quality projects like bridges and tunnels, a wet concrete plant is the best option. For projects that don't require high quality, like sidewalks and roads, a dry concrete plant is the most cost-effective choice. The type of mixing plant chosen depends on the specific project needs. [6]

- **Mobile concrete plant**

The mobile batch plant, also known as a portable concrete plant, is a highly productive, reliable, and cost-effective piece of equipment for producing concrete batches. It enables the user to batch concrete at any location, then relocate to another site and batch concrete. Portable plants are the ideal choice for temporary site projects or even stationary locations where equipment height is a factor, or the required production rate is lower. [6]

Figure 5:Mobile concrete plant

- **Stationary concrete plant**

The stationary concrete plant is engineered to produce high-quality concrete. It boasts large output, high efficiency, high stability, and high specification. Stationary concrete batching plants are dependable and flexible, easy to maintain, and have a low failure rate. They are widely utilized in various projects such as roads and bridges, ports, tunnels, dams, and buildings. [6]

Figure 6:Stationary concrete plant

1.3 Concrete Recipes:

American and European Codes for Ready-Mix Concrete differ in design, manufacturing, and delivery. American Code emphasizes safety and quality, while European Code focuses on energy efficiency and sustainability. Specific differences include compressive strength, cement content, water-to-cement ratio, and concrete temperature. Overall, the American Code is more stringent, aiming for safety, while the European Code is more flexible, aiming for efficiency and environmental performance. In the table (3) that shows the difference between the American code and the European code in the ready-mix concrete industry.[7]

Table 3:The difference between the American code and the European code in the ready-mix concrete industry

Criteria	American Code	European Code
Material selection	Allows for a variety of materials	Focuses on using more sustainable materials
Mixing proportions	Based on water-to-cement ratio	Based on cement content
Quality control	Focuses on accuracy of mixing and quality control	Focuses on improving manufacturing processes
Compressive strength	Minimum of 2,800 psi at 28 days	Minimum of 3,000 psi at 28 days
Cement content	Up to 700 pounds per cubic yard	Up to 600 pounds per cubic yard
Water-to-cement ratio	Up to 0.50	Up to 0.45
Concrete temperature	Between 40- and 90-degrees Fahrenheit	Up to 100 degrees Fahrenheit

The American Code is generally more stringent than the European Code, prioritizing building and structure safety. In contrast, the European Code is typically more flexible, aiming to enhance efficiency and environmental performance. [7]

In Palestine, the American code is adopted for concrete mix design, the American code for concrete mix design has been widely accepted and implemented in Palestine due to its proven effectiveness and reliability. This code provides comprehensive guidelines for determining the appropriate proportions of cement, water, aggregates, and admixtures to achieve the desired strength and durability of concrete. By adhering to this established standard, Palestinian construction projects can ensure the consistent and high-quality performance of their concrete structures.

1.4 Problem Statement:

Based on our research of the labor market, concrete factories in Palestine encounter significant challenges that mirror the actual working conditions and the prevailing environmental factors.

1. Concrete factories in Palestine face a significant challenge due to the lack of programs specifically designed to address their unique needs.
2. Discrepancies can arise between the measured materials and the values entered by the civil engineer in the concrete mix program, often attributed to inaccuracies in the cumulative scale.
3. During winter, the increased water absorption of the aggregate directly impacts the amount of water added to the mixture, consequently affecting the quality of the concrete.

4. Human factors, such as communication challenges between the control room engineer and the mixer driver, as well as the complexity of managing multiple orders, can contribute to operational problems.
5. The risk of the mixture spoiling during transport and the need to determine optimal delivery times remain key concerns.
6. The number of orders executed daily is influenced by the entry and exit patterns of mixer drivers during their work shifts.

1.5 Objectives and scope:

The objectives and scope of industrial automation in concrete factories are aimed at enhancing efficiency, precision, and overall performance in the production process. Here are key objectives and the scope of industrial automation in concrete factories:

1.5.1 Objectives:

Enhanced Efficiency: Automation aims to streamline and optimize various processes within concrete factories, leading to increased production efficiency and reduced operational downtime.

1. Improved Accuracy and Precision: Automation systems utilize sensors and control mechanisms to ensure precise measurements and accurate mixing of concrete components, contributing to the overall quality of the final product.

2. Cost Reduction: By automating repetitive tasks and optimizing resource utilization, concrete factories can reduce labor costs and minimize waste, leading to overall cost savings.
3. Consistent Quality: Automation helps maintain consistency in the quality of concrete by controlling variables such as mixing ratios, curing conditions, and other critical parameters.
4. Increased Safety: Automation can handle hazardous tasks and reduce the need for manual intervention in risky environments, contributing to a safer working environment for factory personnel.
5. Remote Monitoring and Control: Industrial automation enables remote monitoring and control of concrete production processes, allowing for real-time adjustments and troubleshooting without the need for on-site presence.

1.5.2 Scope:

1. Batching and Mixing Automation: Automation systems can control the batching and mixing processes, ensuring accurate proportions of raw materials, water, and additives to achieve the desired concrete properties.
2. Material Handling Automation: Automated systems can manage the movement of raw materials, finished products, and other supplies within the factory, optimizing logistics and minimizing manual handling.
3. Quality Control Automation: Automation can integrate quality control mechanisms, such as sensors and testing equipment, to monitor and adjust the concrete's properties during production, ensuring compliance with industry standards.
4. Equipment Maintenance Monitoring: Automation systems can track the condition of machinery and equipment, facilitating predictive maintenance to minimize unplanned downtime and enhance overall equipment reliability.
5. Energy Management: Automation can contribute to more efficient energy usage by optimizing the operation of equipment and systems, leading to reduced energy consumption and environmental impact.
6. Data Analytics and Reporting: Automation allows for the collection and analysis of data related to production processes, enabling informed decision-making and continuous improvement initiatives.

7. Integration with Enterprise Systems: Automation systems can be integrated with broader enterprise resource planning (ERP) systems, connecting concrete factories with other business processes for seamless coordination and data sharing.

By focusing on these objectives and the outlined scope, industrial automation in concrete factories can significantly enhance overall operational effectiveness, product quality, and competitiveness in the market.

1.6 Report Organization

The works done in this thesis are summarized in five chapters as follows:

Chapter 1: Introduction
This chapter takes an overview about automation of ready-mix concrete plants, discusses the objectives of this study, and then explains the problem.

Chapter 2: Literature Review
This chapter examines various studies conducted to analyze different systems for controlling ready-mix concrete plants and enhancing their operation in various ways.

Chapter 3: Methodology
This chapter discusses the methodology for designing control systems in a ready-mixed concrete plant and finding the best solutions to related problems.

Chapter 4: Results and Analysis
This chapter details the outcomes of our project.

Chapter 5: Discussion
This chapter covers a discussion of system design, programming, and implementation.

Chapter 6: Conclusions and Recommendation
This chapter presents the conclusions and future recommendations of the project and what will be done in the future.

Chapter 2: Literature Review

The history of concrete plant automation dates to the early 20th century, when the first automated control systems for concrete mixing were developed. Initially, these systems were relatively simple, but they helped reduce human error and improve the accuracy of concrete mix proportions.[8]

In the 1950s and 1960s, concrete plant automation saw significant progress. More complex automatic control systems have been developed, which can control a variety of operations in a concrete plant, including concrete mixing, pouring, and curing. [8]

In the 1970s and 1980s, concrete plant automation became more popular. Automated control systems have been installed in more and more concrete plants, increasing productivity and improving quality and safety. [8]

In the 1990s and 2000s, concrete plant automation saw further development. Computer-based automated control systems have been developed that can collect and analyze data to improve concrete plant operations. [8]

In the second decade of the 21st century, concrete plant automation continues to develop. Automated control systems are developed using new technologies, such as artificial intelligence and machine learning. In recent years, concrete plant automation has also focused on sustainability and environmental impact. New automated control systems are being designed to optimize energy usage and reduce waste, making concrete production more environmentally friendly. Additionally, remote monitoring and control systems are being developed to allow for greater flexibility and efficiency in concrete plant operations. As technology continues to advance, the future of concrete plant automation looks promising, with even more advanced and sustainable automated control systems on the horizon.[9]

The chapter "Design, Simulation, and Development of Software Modules to Control Elements of a Concrete Production Plant" in the book "New Approaches in Automation and Robotics" explores the control and operation of a concrete production plant. The use of qualitative modeling is highlighted to improve production procedures and product quality. To ensure the reliability of the control system, a simulation tool was utilized that combines traditional numerical methods with advanced qualitative techniques to efficiently manage dynamic processes within the plant. Commercially available qualitative modeling tools and software have been effective in assisting with the operation and control of concrete production machinery. After obtaining the optimal control model through simulation using QMTOOL software, tests were performed on concrete element manufacturing machines. The effectiveness of this approach is determined by various attributes such as analyzing static and dynamic behaviors of machine operations, evaluating the operation of critical subsystems, redefining design specifications to improve machine control, producing reliable descriptions of collaborative factory machines based on qualitative models, planning and testing route planning scenarios safely, and reducing the cost of manufacturing machines while minimizing the risk of breakdown.[10]

Literature studies on production and delivery of RMC are currently limited. Several papers have addressed issues and solution methods related to this topic. For example, Wu and Low (2007) used JIT purchasing threshold value models. Feng, Cheng, and Wu (2004) employed a model based on genetic algorithms and simulation to optimize dispatch schedules, reducing truck waiting times at construction sites. Al-Araidah et al. (2012) developed a model considering costs related to distance, traffic, and late delivery to enhance financial performance. Mistassini's (2004) designed a dynamic routing system for daily distribution of ready-mixed concrete in a multi-plant environment with time windows. Durbin and Hoffman (2008) created a tool for decision making related to scheduling and concrete delivery based on a time-space network with integer side constraints. Lu and Lam (2005, 2009) researched optimizing concrete delivery scheduling and resource provision for improved productivity. Naso et al. (2007) developed a model to coordinate production and JIT transport at partially independent plants. Yan, Lin, and Jiang (2012) studied the RMC production problem and developed a model for planning production and truck dispatch schedules with stochastic travel times. Schmid et al. (2009, 2010) proposed a solution for ready-mixed concrete delivery with multiple plants, construction sites, and various vehicle types. Liu, Zhang, and Li (2014) focused on integrated scheduling of production and delivery of pumps and trucks, considering practical elements to improve efficiency and save costs. For a detailed review, see the work of Kinable, Wauters, and Vanden (2014). Most of these papers consider a one-plant-multi-site approach and design travel times based on deterministic methods. This paper adopts a multi-plant-multi-site approach and models travel times based on stochastic methods with time windows. In this study, we aim to expand the existing literature on the production and delivery of ready-mixed concrete (RMC) by adopting a multi-plant-multi-site approach and modeling travel times based on stochastic methods with time windows. By doing so, we hope to address the limitations of previous research that primarily focused on a one-plant-multi-site approach and deterministic travel time methods. Our approach will provide a more comprehensive understanding of the challenges and opportunities in RMC production and delivery, particularly in scenarios involving multiple plants and sites. Through the utilization of stochastic methods, we seek to capture the inherent variability and uncertainty present in real-world transportation and logistics operations, ultimately contributing to the development of more robust and effective strategies for RMC production and delivery.[11]

The study conducted by Jia Baiyu, Yang Yu, et al. (2014) explored an integrated knowledge management system tailored to meet the needs of ready-mixed concrete companies. It focused on knowledge content, related models, and methods of expressing knowledge based on its classification, with the aim of enhancing enterprise management, supporting production processes, managing production and operating costs, and improving relationships between marketing and customers to achieve maximum benefits. The successful implementation of knowledge management in ready mix concrete companies was highlighted.[12]

To address the issues of practicality and accuracy of the applied knowledge management system model, the paper used the knowledge mining-based quality cost model in the concrete industry as an example and investigated knowledge mining techniques based on the ANN-GA algorithm. The study chose 28-day compressive strength as the output, with five main indicators of water, cement, metakaolin, fine aggregate, and coarse aggregate as input layers affecting quality. These indicators integrated structural and non-structural factors affecting concrete quality, and GA was used to optimize the weights and thresholds of the artificial neural network to obtain the global optimal solution. This indicates that ANN-GA, as a knowledge extraction algorithm, can meet the requirements of convergence rate and prediction accuracy in knowledge management applications. [12]

In this project, our focus was on creating an automated control system for a ready-mix concrete plant using the SCADA system, as well as developing new technologies and designs to enhance practicality and cost-effectiveness for widespread adoption. Furthermore, we explored methods to integrate these systems with other applications to achieve reliable, integrated solutions for improving production efficiency and reducing costs. These efforts are aimed at enhancing the quality of the final product and streamlining production processes to save time and effort. Our constant pursuit of innovation and development is geared towards meeting our customers' needs and ensuring their satisfaction.

Chapter 3: Methodology

3.1 Requirements Analysis:

Developing a concrete plant automation system necessitates the delineation of functional requirements to guarantee the system's efficient attainment of its intended objectives. The following are key functional requirements for a concrete plant automation system:

1. Batching System:
    - Accurate Measurement: Ensuring precise measurement of raw materials (cement, aggregates, water, and admixtures) for each batch.
    - Flexibility: Allowing for the configuration of different concrete mix designs.
    - Automatic Batching: Enabling automatic batching based on predefined mix proportions.
2. Material Handling:
    - Conveyor Control: Managing conveyor systems for the transportation of materials between different process stages.
    - Storage Management: Controlling material storage and retrieval systems for raw materials and finished products.
3. Moisture Control:
    - Aggregate Moisture Control: Incorporating sensors to measure and adjust for aggregate moisture content.
4. Quality Control:
    - Real-time Monitoring: Implementing a system for real-time monitoring of concrete quality parameters.
    - Testing Integration: Facilitating integration with quality testing equipment for on-site testing of concrete properties.
5. Recipe Management:
    - Recipe Storage: Storing and managing a database of concrete mix recipes.
    - Version Control: Allowing for versioning of mix recipes to track changes and improvements.
6. Process Automation:
    - Automated Start/Stop: Enabling automatic start and stop of the plant based on predefined schedules or demand.
    - Fault Detection: Implementing a system for detecting and responding to equipment malfunctions or deviations from set parameters.
7. Reporting and Documentation:
    - Data Logging: Logging critical process data for future analysis and troubleshooting.
    - Reporting: Generating regular reports on production efficiency, material usage, and quality metrics.
8. User Interface:
    - Intuitive Interface: Designing a user-friendly interface for operators to monitor and control the plant.

- Alarm System: Implementing an alarm system to notify operators of any issues or deviations.

9. Security and Access Control:
   - User Authentication: Implementing secure user authentication to control access to system functions.

These functional requirements serve as the foundation for the development of a comprehensive concrete plant automation system, enhancing efficiency, accuracy, and overall productivity. It is important to note that specific requirements may vary based on the scale and complexity of the concrete plant.

3.2 System design:

The control interface for ready-mixed concrete factories was designed based on our study of the labor market. It considered some of the problems faced by operators working in the factories and incorporated advice from them. After examining various control interfaces and programs, we developed our own, ensuring it was designed in a simple and user-friendly manner while encompassing all necessary functions required for efficient plant operation.

The items within the interface are organized logically, facilitating quick search and access to information. Moreover, the interface was crafted with modern and advanced technologies to guarantee high performance and swift response times. We identified the factory's working mechanism, including processes such as weighing, branching, loading, mixing, equipment protection, and minimizing error rates in the scales to produce concrete mixes with the required specifications.

To enhance operational efficiency, a function was integrated to enable remote monitoring of the factory's operations through the use of modern communication technologies. This empowers operators to monitor activities and make effective and timely decisions. Additionally, a multilingual user interface has been implemented, ensuring usability for all factory workers, irrespective of their mother tongue.

The interface is designed to be customizable according to operators' specific needs, thereby increasing work efficiency and facilitating adaptation to different requirements.

Concrete production processes:

The diagram in Figure 7 shows the operating mechanism of the dry ready mix concrete plant, which is widely used in Palestine. The process is done as follows: First, the type and quantity of the required mixture are selected from the program. After that, the factory is activated and all material gates (aggregate, sand, cement) as well as pumps (water and chemicals) are opened, and the weighing process begins until the required weight for each component is reached. Next, the aggregate and sand are unloaded onto the conveyor for transportation to the mixing truck. Then, cement and water are simultaneously released into the mixing truck. Finally, the chemicals are unloaded into the mixing truck.

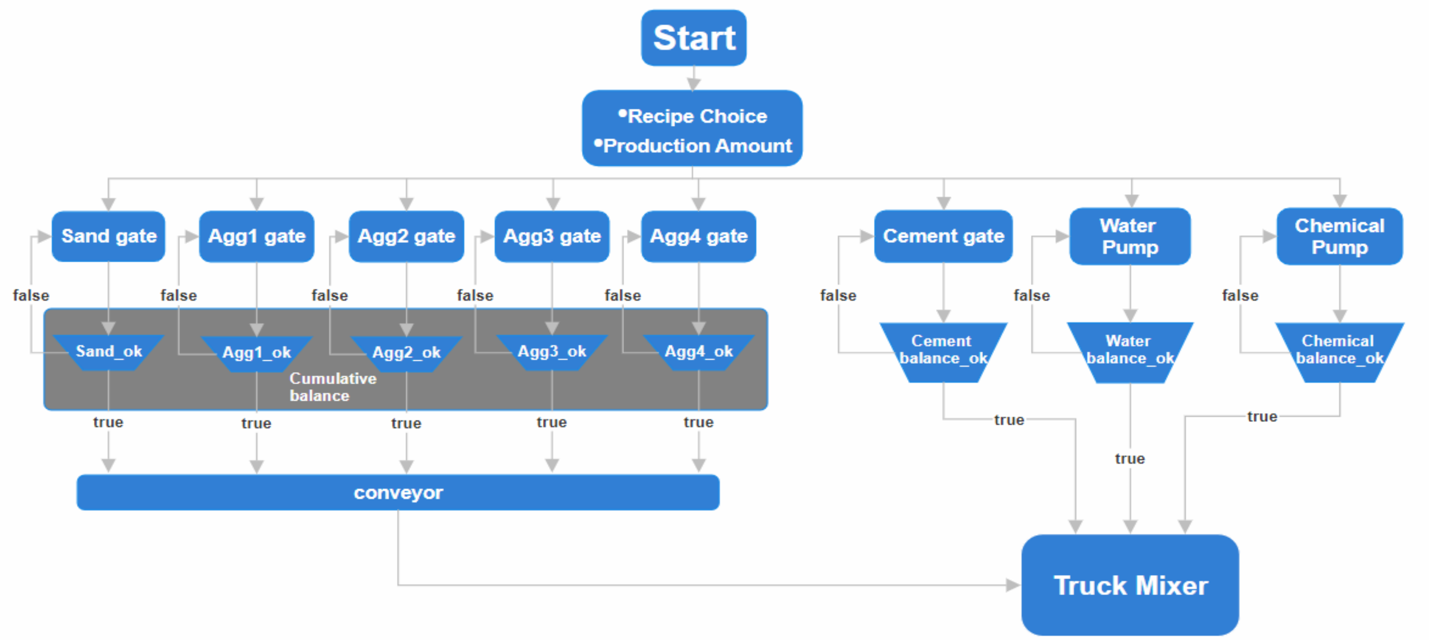


Figure 7:A diagram drawn up to illustrate the practical mechanism of a dry ready mix concrete plant.

The flow chart in Figure 8 shows the operation of a wet ready mix concrete plant. The process includes selecting the type and quantity of mixture required, activating the plant, opening material gates and pumps, and beginning the weighing process until the desired weight is reached for each component. Then, the aggregate and sand are transported to the mixing host via conveyor, while the cement and water are released to the mixing host. In addition, the chemicals are unloaded into the mixing truck. The central mixer then combines the coarse stone, fine stone, sand, cement, water and additives to produce the final concrete at pre-determined composition ratios.

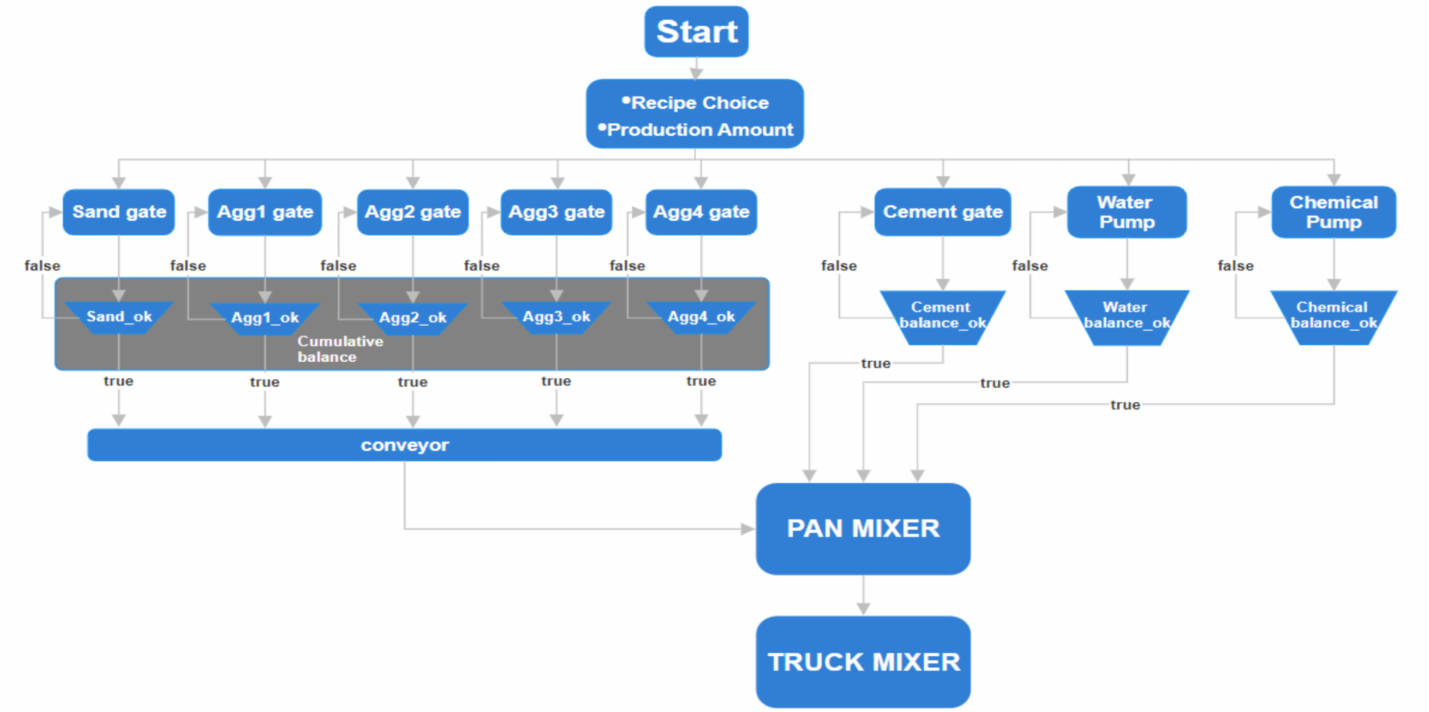


Figure 8:A diagram drawn up to illustrate the practical mechanism of a wet ready mix concrete plant.

To control the operation of a concrete plant, it is essential to consider the hierarchy depicted in Figure 9. The automation pyramid visually illustrates the various levels of automation within the plant, providing a comprehensive understanding of the factory's complexity. At the base of the pyramid is the field level, which consists of sensors and actuators that directly interact with the physical processes of the plant. The next level is the control level, where PLCs (Programmable Logic Controllers) and other control devices manage the operation of individual machines or processes. Above that is the supervisory level, which oversees the entire plant and may include SCADA (Supervisory Control and Data Acquisition) systems. Finally, at the top of the pyramid is the enterprise level, where higher-level decision-making and resource planning occur. Understanding and effectively managing the interactions between these levels is crucial for optimizing the performance and efficiency of a concrete plant.[13]

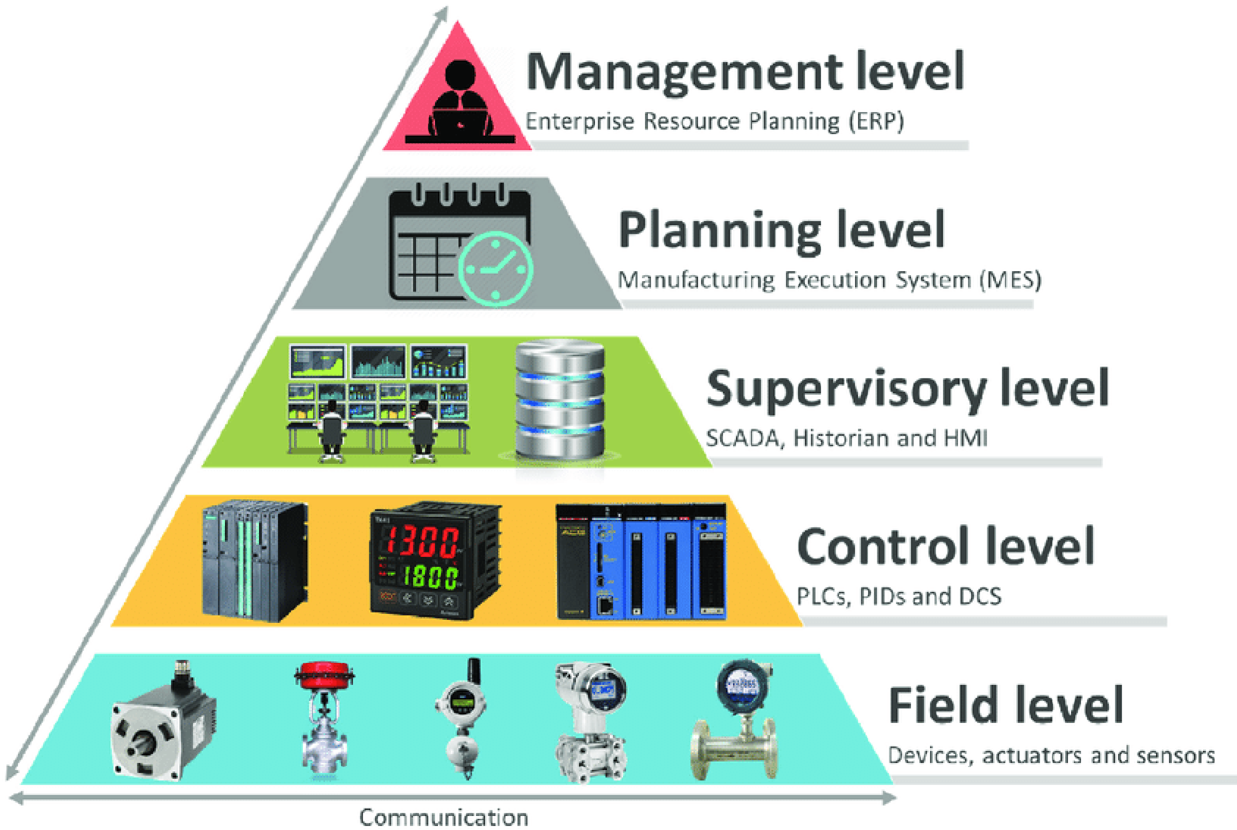


Figure 9:Automation pyramid

3.3 System Architecture and Hardware Components:

3.3.1 Level 0- Field Level/Production Process (devices, actuators and sensors):

This layer contains devices, actuators, and sensors located in the field or on the production floor. The field level represents the production floor where physical work and monitoring take place. Examples of field level devices include electric motors, sensors, hydraulic and pneumatic actuators for moving machinery, as well as proximity switches to detect the movement of specific materials. Switches that detect similar movements are also commonly found at this level. Field-level devices are vital to the smooth running of production operations, providing real-time data and control of various machines and equipment used in manufacturing and industrial environments and providing data in fractions of a second. These devices play a critical role in ensuring efficiency, safety and optimal performance of the production floor. [13]

Below is a description of the sensors, actuators, and devices at this level for ready mix concrete plants:

- Sensors:

- **Load Cell:**

A load cell transforms a force like tension, compression, pressure, or torque into a signal (electrical, pneumatic, or hydraulic pressure, or mechanical displacement indicator) that can be measured and standardized. It serves as a force transducer. As the force on the load cell increases, the signal changes proportionally. The most common load cell types for industrial applications are pneumatic, hydraulic, and strain gauge. A common example of a mechanical displacement indicator is non-electronic bathroom scales, where the applied weight (force) is indicated by measuring the deflection of springs supporting the load platform, technically a "load cell".[14]

Commonly used in concrete plants to measure the weight of aggregate, cement, and additives.

The S-type load cell: is the most commonly used sensor for measuring tension and pressure between solids. It is also known as a tension pressure sensor due to its S-shaped design. These load cells are highly accurate, typically with ±0.025% non-linearity, and are suitable for measuring both tensile and compressive forces. The spring element is positioned in the center beam of the load cell. Interface S-Type Load Cells are cost-effective, accurate, easy to mount, and offer flexibility for tension and compression testing. They are available in capacities ranging from 25kg to around 30 tonnes, primarily utilizing metal foil strain gauge technology. These load cells are a popular choice for applications due to their accuracy and compact design. [14]

Figure 10:S-type load cell

- **Moisture Sensor:**

Moisture Measurement in Aggregates and Sand

Initially developed for the ready-mix and pre-cast concrete industries to improve batching accuracy and slump control, these systems have proven beneficial in other industries using sand or aggregates during processing. Advantages include a reduction in spoiled batches, the ability to batch the correct sand weight regardless of water content, and the capability to set high or low moisture level alarms. Modern plants can weigh aggregates with an accuracy of up to ± 0.5%. Any moisture variation in a batch of sand or aggregates between 2% to 10% affects the accuracy and proportions of the weighed materials, as water is effectively weighed instead of dry materials.[15]

Moisture sensors can measure moisture levels in materials being discharged from bins, on conveyor belts, or within vibratory feeders. Placed directly in the material flow, the sensors take 25 measurements per second as the sand or aggregate flows over the ceramic measurement surface. These measurements are then transmitted to the plant control system in real time. This enables manufacturers to precisely control water addition during processing, ensuring consistent batch quality while reducing material wastage. The sensors offer various mounting options and can be installed in different locations based on plant-specific needs. Optimal results are achieved by mounting the sensor in the neck of a bin or underneath the gate. The popular sensor for this type of mounting is the Hydro-Probe, which takes readings as the sand or aggregate is released from the bin and flows over the sensor faceplate. If positioning the sensor in this location is challenging, good results have also been obtained by mounting the sensor inside the bin. [15]

Figure 11:Moisture Sensor

To measure moisture in sand and aggregates flowing on conveyors and belt feeds, a Hydro-Probe or a Hydro-Probe Orbiter can be mounted above the belt. Readings can then be taken as the material passes along the belt, flowing around the sensor. [15]

Figure 12:Hydro-Probe installed above sand conveyor belt

Figure 13:Moisture Sensor located under Aggregate Bin

- **Proximity Sensors:**

Proximity sensors are commonly used in concrete plants for various purposes, contributing to the automation and efficiency of the production process. Here are some ways proximity sensors may be employed in a concrete plant [16] :

Figure 14 :Proximity Sensors

1) Aggregate Batching: Proximity sensors can be used to detect the presence or absence of aggregates in the storage bins. This information helps in automating the batching process, ensuring that the correct amount of each aggregate is dispensed into the mixer. [16]

2) Cement Silo Level Monitoring: Proximity sensors can be installed at different levels within cement silos to monitor the level of cement. This data is crucial for inventory management and ensures that an adequate supply of cement is always available for the mixing process. [16]

3) Admixture Dispensing: Proximity sensors may be used to monitor the dispensing of admixtures. By detecting the presence of containers or valves, the system can control the addition of admixtures to achieve the desired concrete properties. [16]

4) Gate Positioning: In some plants, gates or valves control the flow of aggregates or cement. Proximity sensors can be employed to detect the position of these gates, ensuring they are open or closed as required during the batching process. [16]

5) Monitoring mixer drum rotation in wet concrete plants: Proximity sensors can be used to monitor mixer drum rotation. This information is vital to ensure that the concrete mixture is well mixed and reaches the desired consistency before unloading. [16]

6) Conveyor Belt Monitoring: Proximity sensors may be installed along conveyor belts to detect the presence of aggregates and other materials. This information is essential for maintaining a steady flow of materials during the production process. [16]

7) Truck Loading: Proximity sensors can be used to automate the loading of ready-mixed concrete into delivery trucks. Sensors can detect the position of the truck, ensuring accurate loading and preventing overfilling. [16]

8) Safety Applications: Proximity sensors can also play a role in safety by detecting the presence of personnel in specific areas. This information can trigger alarms or shut down certain equipment to prevent accidents. [16]

The specific use of proximity sensors in a concrete plant depends on the plant's design, the level of automation, and the desired efficiency. These sensors help in monitoring and controlling various aspects of the production process, contributing to the overall quality and consistency of the ready-mixed concrete. [16]

- **RFID Sensors:**

RFID, or radio frequency identification, is a type of automatic identification technology that uses radio frequencies to capture and transmit data. It consists of tags and a reader. Each tag contains an integrated circuit chip and an antenna, enclosed in a protective shell. The reader includes an antenna and a scanner to communicate with the tags.[17]

RFID tags can be active (battery-powered) or passive (powered by the reader through radio waves). They can also be categorized by working ranges: near-field RFID systems operate on lower band RF (e.g., 13.56 MHz) and use an inductive power mechanism, while far-field systems run on higher band RF (about 915 MHz) and use an electromagnetic powering mechanism to achieve interrogation distances greater than 10 feet. [17]

RFID sensors improve automation, tracking, and monitoring in concrete plants. They are used for raw material tracking, inventory management, batching process automation, quality control, equipment and asset tracking, truck loading and dispatch, personnel tracking, and maintenance scheduling. This integration enhances efficiency, accuracy, and traceability in production and logistics. [17]

Figure 15:RFID sensors

3.3.2 Level 1-Control Level/Sensing and Manipulation (PLC, DCS and PID):

At this level, you control and manipulate the devices in the field level that actually do the physical work. They take information from all of the sensors, switches, and other input devices to make decisions on what outputs to turn on to complete the programmed task. PLCs contain a processor, memory to hold their programming and other data and input and output modules. A PID is usually integrated into the PLC, DCS and stands for proportional–integral–derivative. That is what can keep a variable within a set of parameters. [18]

DCS (Distributed Control System), PLC (Programmable Logic Controller), and PID (Proportional-Integral-Derivative) are terms associated with control systems, each serving distinct purposes and offering unique functionalities.

- DCS (Distributed Control System):

Purpose: DCS is utilized to control and oversee intricate industrial processes. It is distributed as it involves multiple controllers spread across a system.

Functionality: DCS is tailored for large-scale systems where multiple processes or units require control and monitoring. It utilizes a networked architecture, enabling centralized control and distributed processing units.

Applications: Commonly found in industries such as power plants, chemical plants, and manufacturing facilities where numerous control loops and processes necessitate coordination. [18]

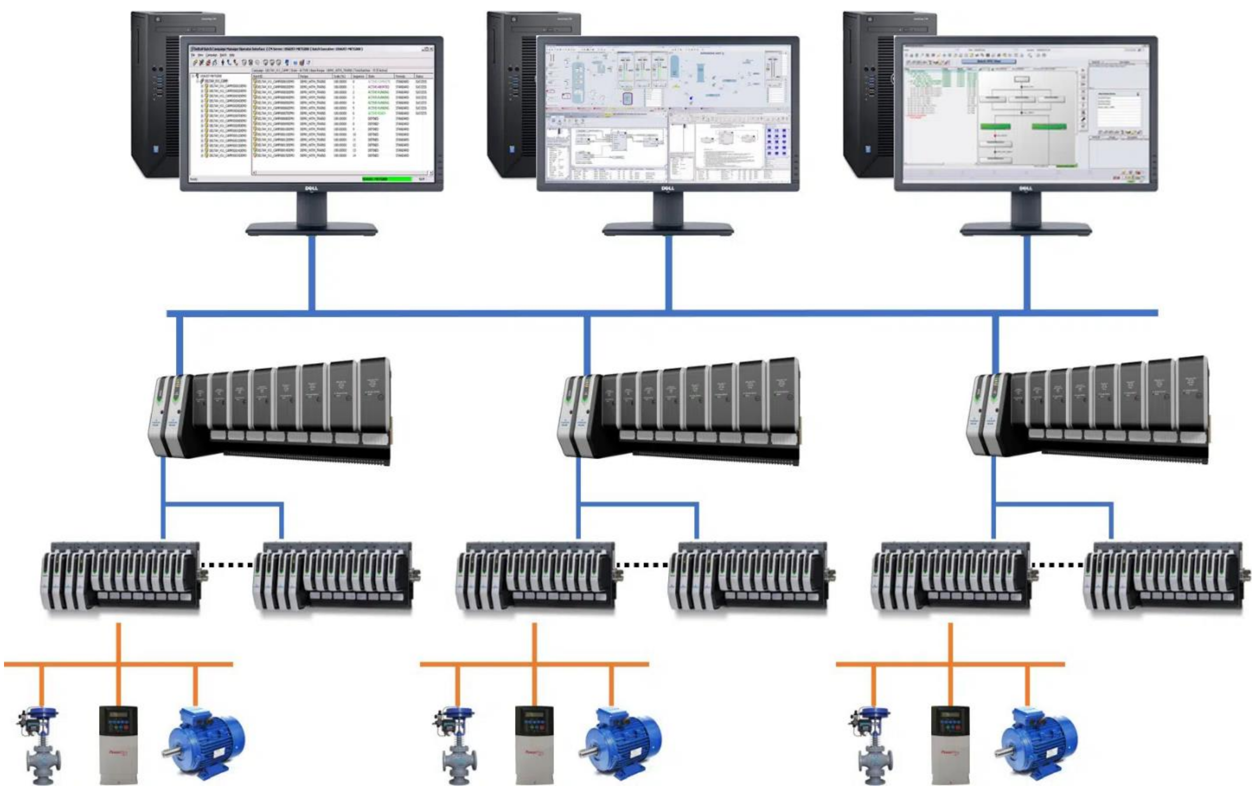


Figure 16: Distributed Control System

→ Who are the largest manufacturers of Distributed Control System (DCS) Market worldwide?

ABB, Yokogawa, Honewell, Emerson, SIEMENS, HITACH, Foxboro, HollySys, Supcon , Sciyon , Guodia , Xinhua, Shanghai Automation and Luneng

- PLC (Programmable Logic Controller):

Purpose: PLC is a ruggedized digital computer used for industrial automation, designed to execute real-time control functions.

Functionality: PLCs are programmable and can be configured to control various industrial processes and machinery. They are frequently employed for discrete control applications, such as assembly lines or manufacturing processes.

Applications: Widely used in manufacturing and process control, especially in scenarios requiring sequential or logic-based control. [18]

Figure 17:PLC

→ Who are the largest manufacturers of Programmable Logic Controller (PLC) Market worldwide?

Siemens, Rockwell Automation, Schneider Electric, Mitsubishi Electric, ABB, Omron, Delta Electronics, Yokogawa Electric, Honeywell, DALTA, Fatek and Panasonic.

The PLC can be divided into several parts, as shown in the following figure:

1. Power Supply:

- It converts alternating current into direct current to feed the rest of the PLC parts.
- Some PLC devices operate at VAC 220, so they are connected directly to the electricity source without a power unit.
- In small PLC systems, the feeder is used to feed field devices (inputs and outputs).
- In large systems, an external feeder is used to feed field devices.[19]

Figure 18 :PLC Schneider

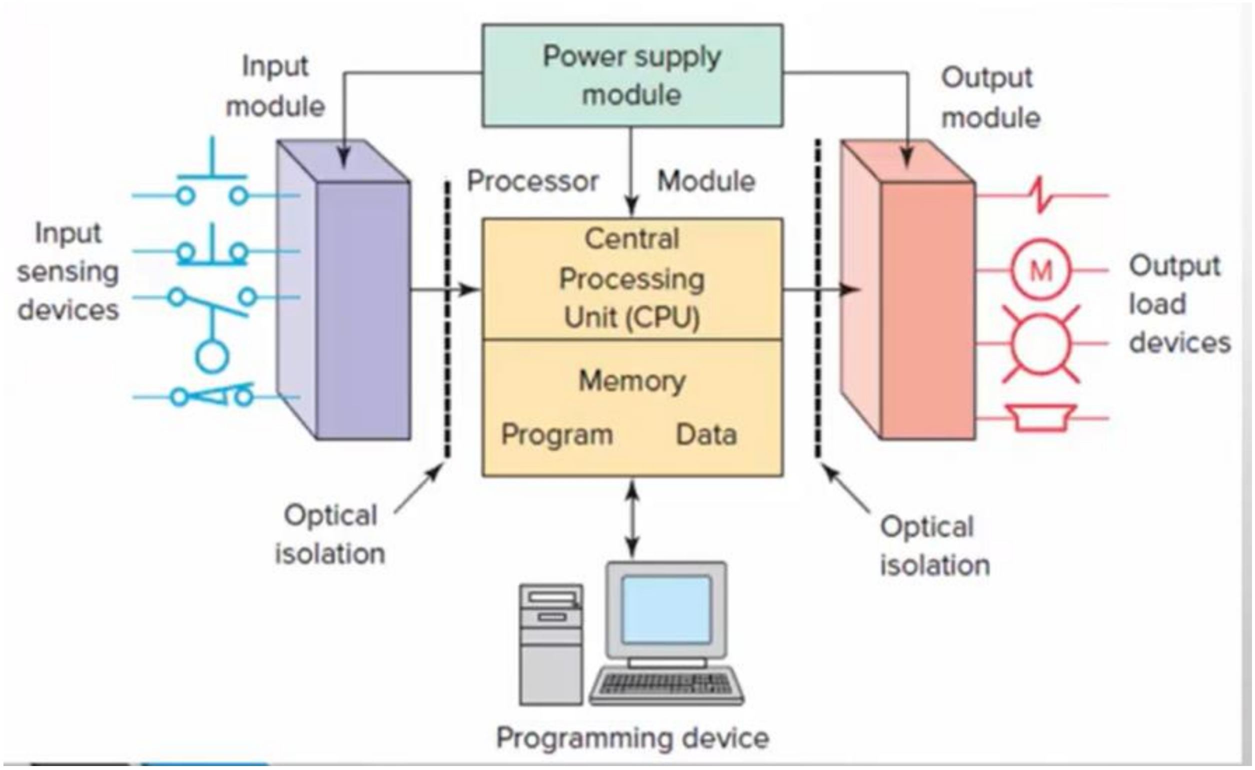


Figure 19:PLC part

2. CPU:

- The central processing unit is the brain of the PLC.
- The CPU processes the signal data of the input devices and sends the results of the operations to the output devices according to the program stored in memory.
- Each CPU has special specifications that affect its speed in performing operations.
  The central processing unit (CPU) is the PLC's brain. It processes input device signal data and sends operation results to output devices based on the stored program in memory. Each CPU has unique specifications influencing its operational speed. [19]

Figure 20:CPU type

3. Input Modules

- The input modules receive signals from input devices and format them for processing by the central processing unit.
- Input units can be digital, processing logical signals (0 or 1), or analog, with variable values like (10), (0), or (20-4). Analog-to-digital conversion circuits transform incoming analog signals from analog inputs into digital signals for CPU processing. [19]

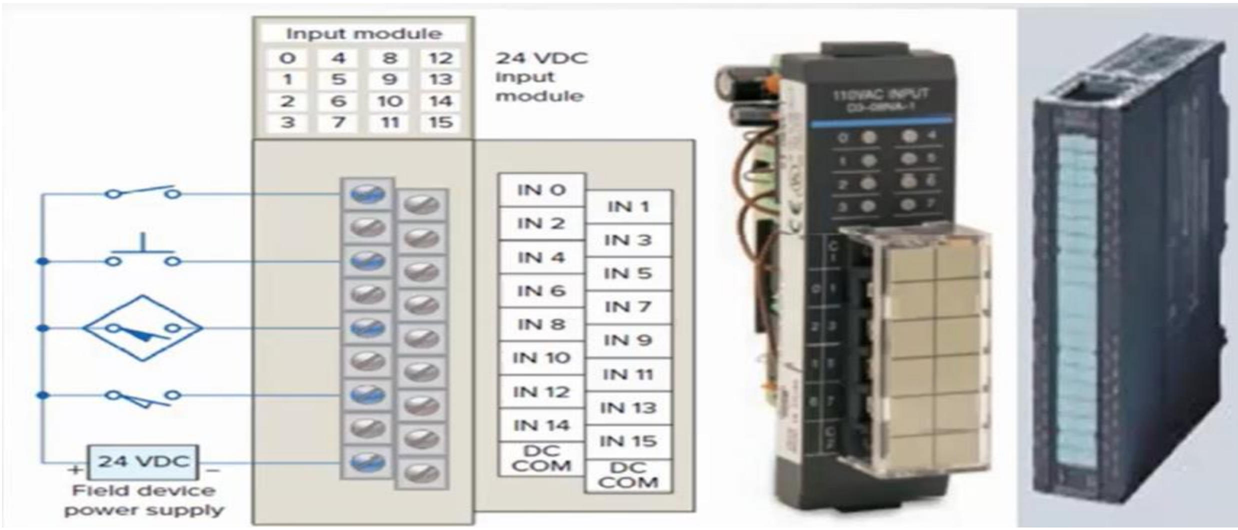


Figure 21:Input module

4. Memory:

Memory is the component that stores data, information, and programs. Writing is the process of storing data in memory, while reading is the process of retrieving data from memory. PLC memory is categorized into volatile and nonvolatile types:

a) Volatile memory loses all stored data when power is lost and allows for data modification. It is user-friendly and suitable for many applications when a battery is used.
b) Nonvolatile memory retains data even when power is disconnected.

1. Read-Only Memory (ROM): is a type of nonvolatile memory that is programmed during manufacturing. It typically holds data essential for the operating system and PLC functionalities. [19]

2. Random Access Memory (RAM): is a type of read and write memory that enables fast reading and writing processes due to its sequential access capability. RAM serves as temporary data storage and is volatile, requiring a battery to sustain its contents in PLC devices. CMOS-RAM technology is commonly used in PLCS, drawing a small current and preserving data for 2 to 5 years with lithium batteries. Some processors utilize a capacitor to help the RAM retain data for up to 30 minutes if power is disconnected. [19]

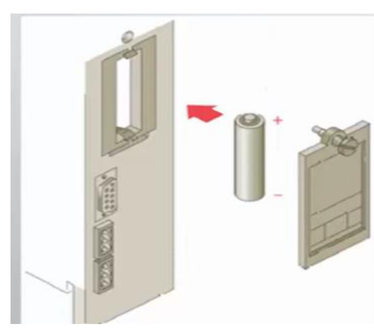


Figure 22:lithium batterie

3. Erasable Programmable Read Only Memory (EPROM): EPROM is a non-volatile memory that stands out from ROM as it can be erased and altered using ultraviolet rays. It is primarily utilized for storing and transferring PLC programs, providing a certain level of program security against unauthorized modifications. [19]

4. Electrically Erasable Programmable Read Only Memory (EEPROM): EEPROM, another non-volatile memory type, offers the same programmability as RAM without the need for a battery or ultraviolet light for content modification. Its content is easily changed using a programming device, serving as a storage medium for PLC programs. [19]

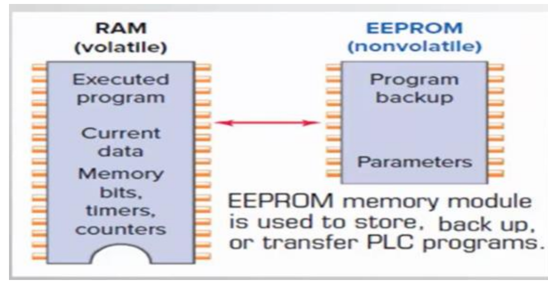


Figure 23:RAM & EEPROM

5. Flash EEPROM: Similar to EEPROM, Flash EEPROM can be used for program backup but excels in faster saving and retrieval processes. Content modifications do not require a special programming device, allowing for changes without disconnecting from the PLC. Some processors automatically reserve space for this memory, safeguarding critical data in case of power outages to ensure uninterrupted PLC functionality. [19]

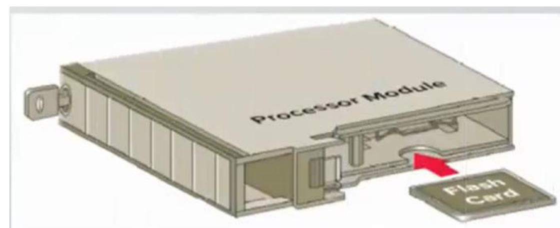


Figure 24:Flash memory

❖ Memory size depends on several factors:

1. The amount of memory required depends on the complexity of the program.
2. The PLC contains only one program in memory. It is not possible to store more than one program in the memory at the same time. If a new program is copied or loaded into the memory, this means erasing or losing the old program.
3. Or Flash EEPROM, which some CPUs contain a Memory Cartridge and are of the EEPROM type, through which the program can be copied from one PLC to another of the same type.
4. One of the most popular batteries used with a PLC device is the lithium battery. It is characterized by its constant voltage. One of its disadvantages is that its voltage reaches zero as soon as its life span ends without warning. It is preferable to change the battery every two years.

5. There are some types of capacitors called Super Capacitors, which help the RAM to retain the program for up to 50 hours after the power is interrupted and the battery is lost.

❖ PLC Classification Based on Inputs and Outputs

The difference in industrial processes has led to the companies producing PLCS resorting to manufacturing different types of devices in order to cope with the size of the different industrial processes (one PLC production company has more than

PLC type).

The classification of PLCS in markets depends on several factors, the most important of which are the function and number of inputs and outputs factors, price and volume.

PLCS can be classified into four types in terms of the number of inputs and outputs as follows:

1. Nano PLCs: It is the smallest size of PLCS and contains less than 15 input and output points.
2. Micro PLCs: It contains a range from 15 to 128 input and output points.
3. Medium PLCs: It contains a range from 128 to 512 input and output points
4. Large PLCs: It contains more than 512 input and output points.

❖ PLCs can be categorized into two types based on how the input and output modules are integrated:

- Compact or fixed PLC: This is a modern type where all components, including the feeder unit, input unit, output unit, and memory, are enclosed within a single box. It is expandable through a network port for adding more modules.

Figure 25:Compact or fixed PLC

- Modular PLS: This was the initial type introduced and is known for its capacity to handle numerous inputs, outputs, and memories. It can support large programs and advanced functions, with modules installed on a base independently.

Figure 26:Modular PLS

❖ In general, PLCS applications can be classified into three types as follows:

- Single ended or Stand-alone PLCs Application:

In this application, a single PLC controls a single process, as it is an independent unit and is not connected to any other PLC or computer. In these applications, the size and development factors of the process that is to be controlled are clear during the selection of the PLC. Most of these applications require PLCS of small types.

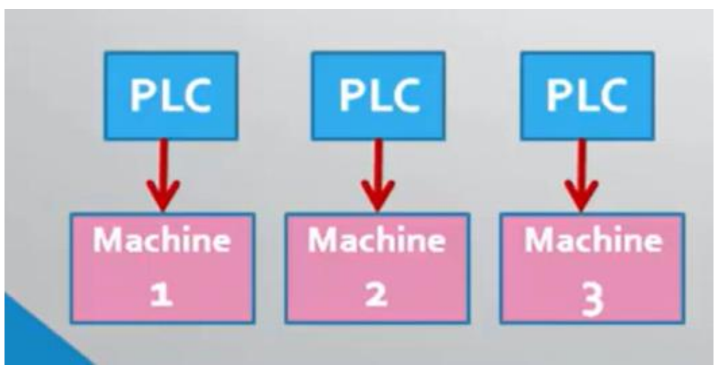


Figure 27:Single ended or Stand-alone PLCs Application

- Multitask PLCs Application:

In this application, a single PLC controls a group of processes. In these applications, the number of inputs and outputs to the PLC is the most important factor. Also, if the application is part of a large process, this requires the PLC to be connected to the central PLC or computer.

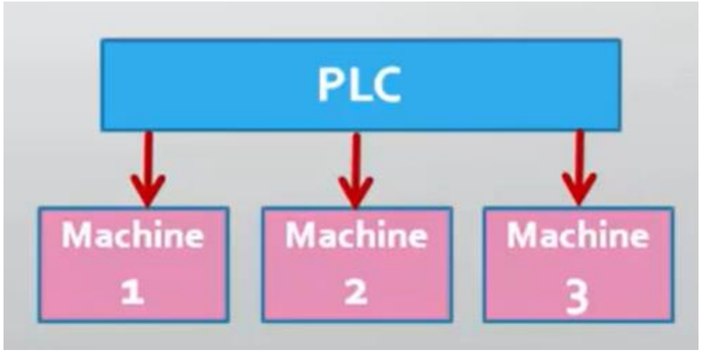


Figure 28:Multitask PLCs Application

- Control Management PLCs Application:

In this application, the PLC controls a group of other PLCS. In these applications, a PLCS requires large processors and the ability to communicate with other PLCS and computers.

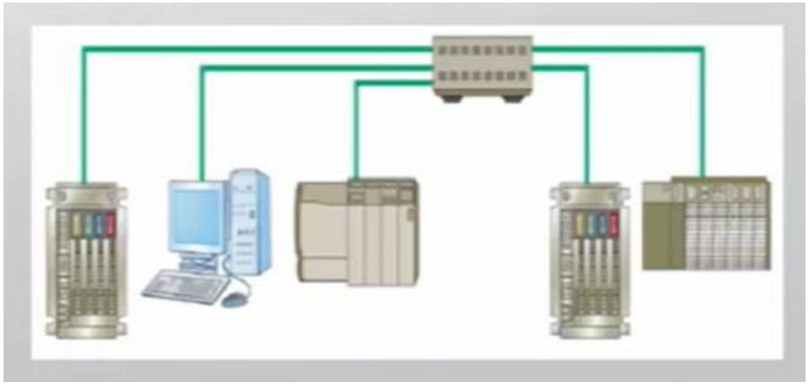


Figure 29:Control Management PLCs Application

There are many companies that produce PLCs, and each company has several different types of PLCs that it produces, and each series has a special program to program and connect them. As is the case in the following figures 30,31,32,33,34.

Figure 30:companies that produce PLCs

Figure 31:Siemens PLC and Program

Figure 33:Schneider PLC and Program

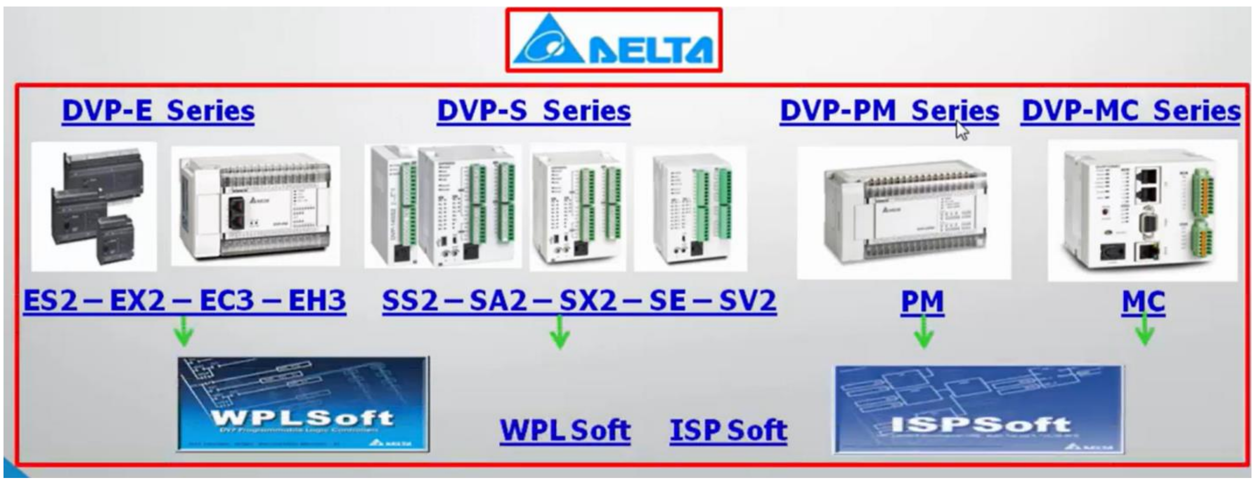


Figure 32:DALTA PLC and Program

Figure 34:Allen-Bradley PLC and Program

- PID (Proportional-Integral-Derivative):

Purpose: PID is a type of control algorithm used in feedback control systems to regulate a process.

Functionality: PID controllers utilize feedback from a process to continuously adjust the control output to maintain a desired setpoint. The three components (Proportional, Integral, and Derivative) contribute to the control action based on the error (difference between the setpoint and actual process variable).

Applications: PID controllers are employed in various systems, including temperature control, pressure control, and flow control. They are versatile and widely used in both DCS and PLC systems. [18]

In conclusion, DCS and PLC represent broader control system architectures, with DCS being more suitable for distributed and complex processes, while PLC is often utilized for discrete control applications. PID, on the other hand, is a specific control algorithm employed within both DCS and PLC systems to regulate processes and ensure they operate at desired setpoints. [18]

3.3.3 Control Systems in Concrete Plants: A Comprehensive Guide to Choosing Between PLC, DCS, and PID

When choosing between Programmable Logic Controller (PLC), Distributed Control System (DCS), and Proportional-Integral-Derivative (PID) control systems for a concrete plant project, several factors come into play. These include process complexity, control requirements, and project goals. Here are some considerations for selecting PLC over DCS and PID in a concrete plant project:

- Process Complexity:

If the concrete plant has a relatively simple process, a PLC may suffice, as it is well-suited for discrete and sequential control.

- Flexibility and Scalability:

PLCs offer flexibility and scalability, making them suitable for smaller to medium-sized concrete plants. They can easily adapt to changes in the production process and can be expanded or modified without significant challenges.

- Cost Considerations:

PLCs are often more cost-effective than DCS for smaller and less complex applications. If budget constraints are a significant factor, opting for a PLC-based control system may be a practical choice.

- Real-time Control:

PLCs are designed for real-time control and can effectively manage time-critical processes. In a concrete plant, where precise control of mixing, batching, and other processes is essential, PLCs can provide the necessary responsiveness.

- Specialized Functions:

For specialized control functions, such as motion control, PLCs may be a better fit. They can be programmed to handle a wide range of control tasks, and their programming languages are well-suited for discrete and sequential operations.

- PID Control Integration:

While PLCs can handle basic PID control, if advanced PID control strategies are a critical requirement, a dedicated PID controller or a DCS with advanced control capabilities may be more appropriate.

- Integration with Other Systems:

PLCs are often used for stand-alone applications, and they may be more suitable for integration with other control systems or enterprise-level software if needed. DCS, on the other hand, is designed for seamless integration across various processes in a plant.

- Operator Interface:

Consider the operator interface requirements. PLCs typically have simpler human-machine interfaces (HMIs) compared to DCS. If the plant operation doesn't require a highly complex graphical interface, a PLC-based system may suffice.

In summary, the choice between PLC, DCS, and PID control in a concrete plant project depends on the specific needs and characteristics of the plant. PLCs are often preferred for smaller and less complex applications, while DCS may be more suitable for larger and integrated systems. PID control can be integrated into either PLC or DCS based on the level of control sophistication required.

3.4 Software Design and Implementation:

3.4.1 Level 2- Supervisory Level/Monitoring and supervising (SCADA design):

This level is known as the supervisory level. Where the previous level utilizes PLCs, this level utilizes SCADA. SCADA is short for supervisory control and data acquisition.

SCADA is essentially the combination of the previous levels used to access data and control systems from a single location. It usually adds a graphical user interface called an HMI, to control functions remotely. The important thing to remember about SCADA is that it can monitor and control multiple systems from a single location. It isn't limited to a single machine. In addition, SCADA allows for real-time data collection, analysis, and reporting, enabling more efficient and effective decision-making processes. Furthermore, SCADA systems are designed to be highly secure, with advanced encryption and authentication measures in place to protect sensitive information and prevent unauthorized access. Overall, SCADA represents a significant advancement in the field of industrial automation and control, providing enhanced capabilities and functionality for supervisory and monitoring tasks.

After researching various software options for creating a control interface for a concrete plant using SCADA software, we experimented with Siemens software including TIA Portal, WinCC, and others. Ultimately, we determined that DIA VIEW was the best fit for our needs due to its user-friendly interface and excellent features. Additionally, it is available for free download from the Chinese company Delta's website. We utilized this software to design a ready-mix concrete plant.

Figure 35:DIAVIEW software interface

3.4.2 The UI for the program, completed in the of graduation project.

- Main Screen:

After implementing the main SCADA user interface on DIA View, it includes main icons for logging in, logging out, translating, and exiting the program. In addition, there is an order page bar that allows three orders to be prepared simultaneously for customers and there is also a laboratory samples page. This page includes the results of tests of materials and mixtures in the factory's private laboratory. Furthermore, a toolbar is available, featuring sections for factory layout, guide, automatic, timer, username, recipes, settings, alarms, reports, printing, and history. These settings were incorporated following extensive research and visits to various ready-mix concrete factories, considering input from industry experts, and are illustrated in figure 36.

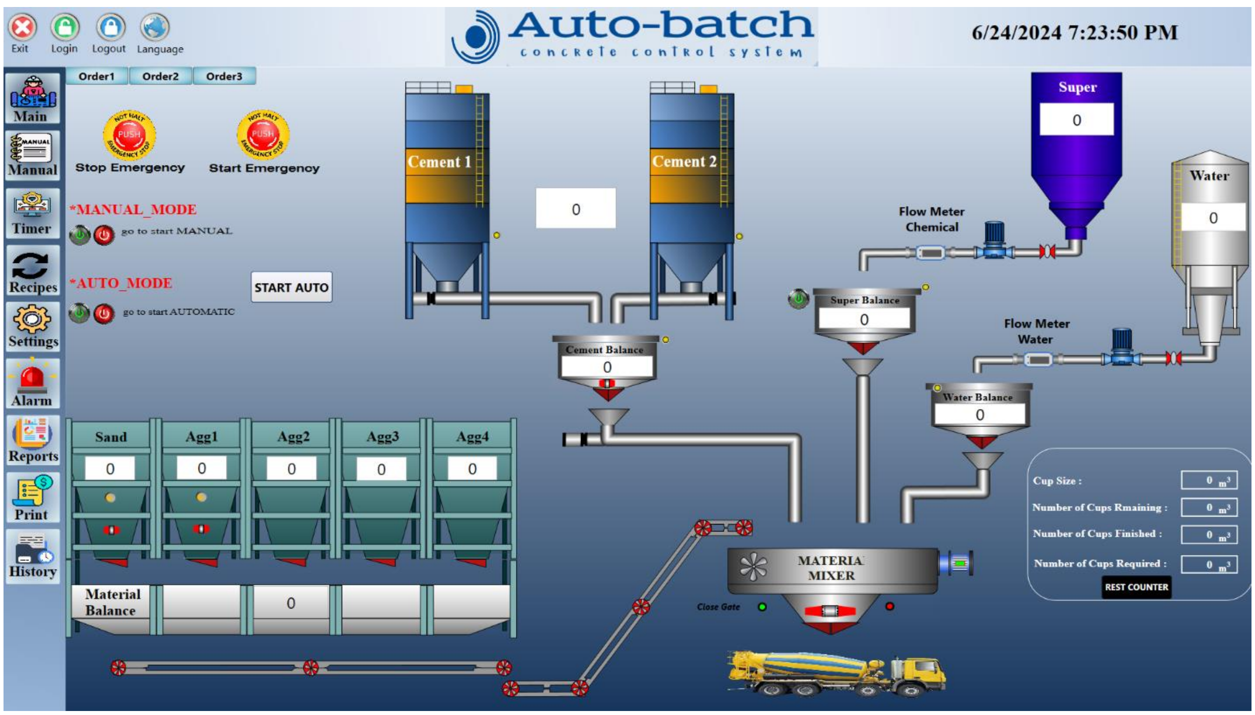


Figure 36:The main interface of the program

- Orders page:

In the user interface requests pages (Automated Concrete Control System), as depicted in Figure 37, control and monitoring of weights and quantities are carried out, along with the display of certain commands and information.

In box (1): The required number of cups and the number of ready cups is shown.

In box (2): Control operation buttons (automatic and manual) and order information, as depicted in Figure 38, are displayed.

In Box (3): Three tables are provided for monitoring and controlling weights.

In box (4): It includes buttons for controlling the operations occurring in the factory during the order.

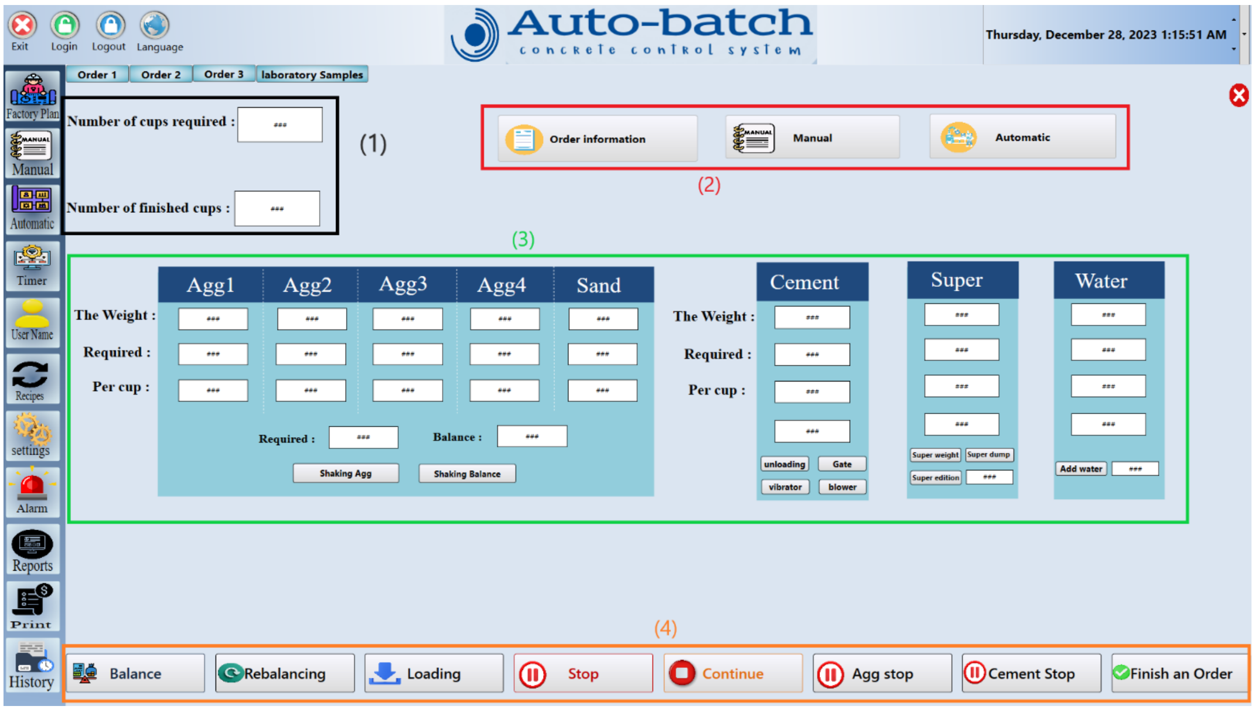


Figure 37:Orders page and control

Figure 38:order information

➢ Manual Page:

Upon accessing the manual page, which displays control of all operations within the concrete plant the user will have full control over the concrete plant's operations and can easily navigate through the manual to find information on specific processes and procedures. This comprehensive guide ensures that all tasks can be carried out efficiently and safely, maximizing productivity and minimizing errors. The Python code was written to simulate manual operation and can be found on the Appendices page., as depicted in Figure 39.

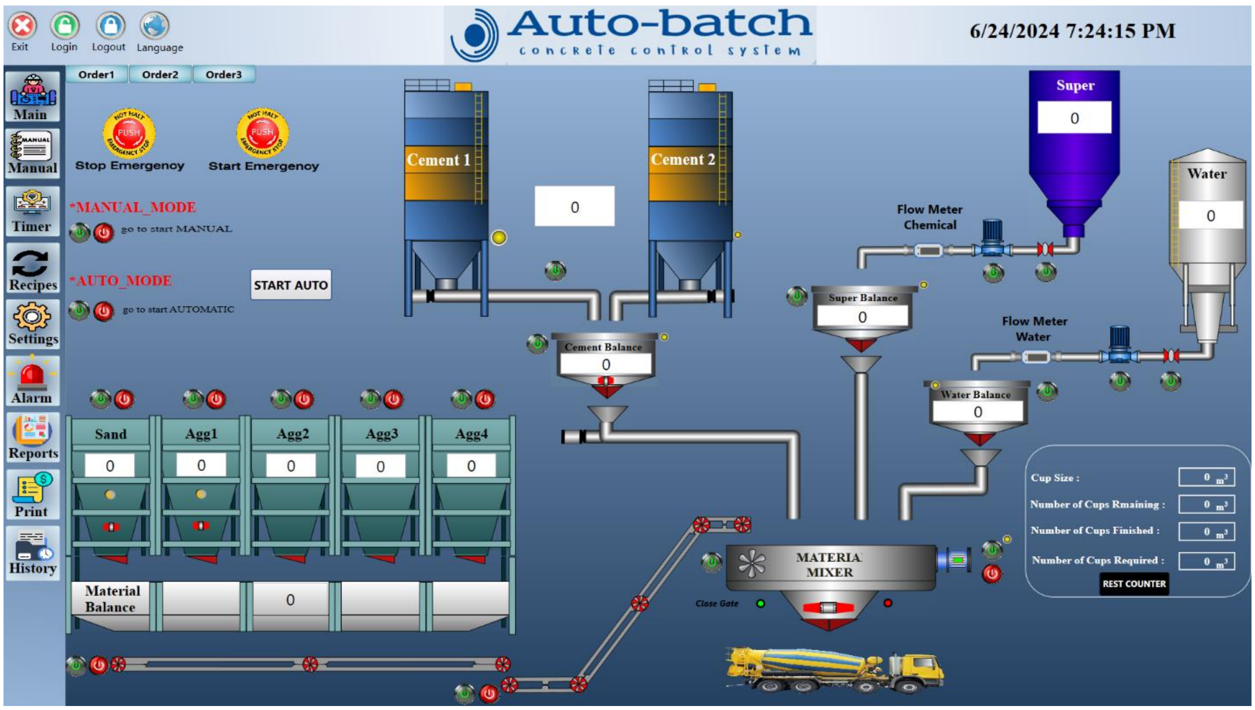


Figure 39:Manual Page

- Setting Page:

When you enter the settings page, you can add a new username and create a password for it. You can also change the username and password of the current user. Additionally, you can create login permissions for all employees within the plant, including engineers, managers, and operators. For example, you can create login permissions for an engineer to access the recipes page, enter the required weights for each cup, and set up, adjust, and calibrate the scales through the page, as shown in Figure40.

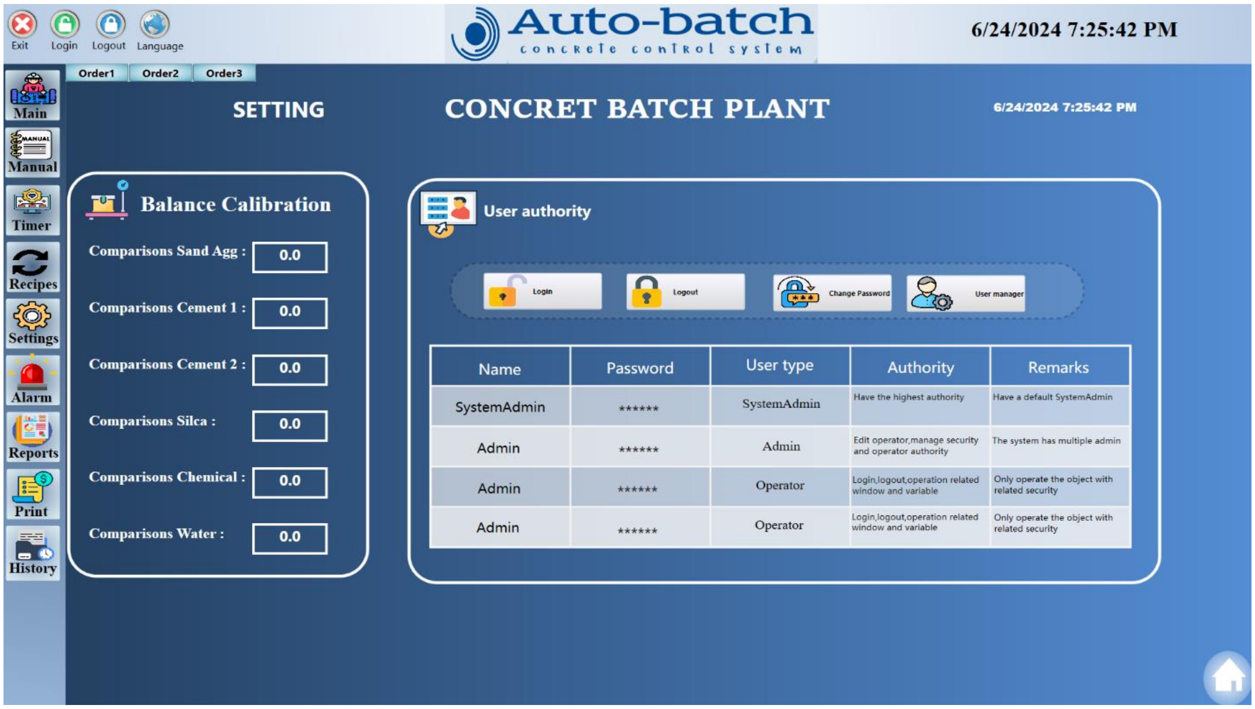


Figure 40:Setting Page

➢ invoice page:

When you open the invoice page, this page appears at each end of an order, and contains the order information that was filled out form the orders page. Part of it is directed at the factory and the other part is directed to the customer. as depicted in Figure (41).

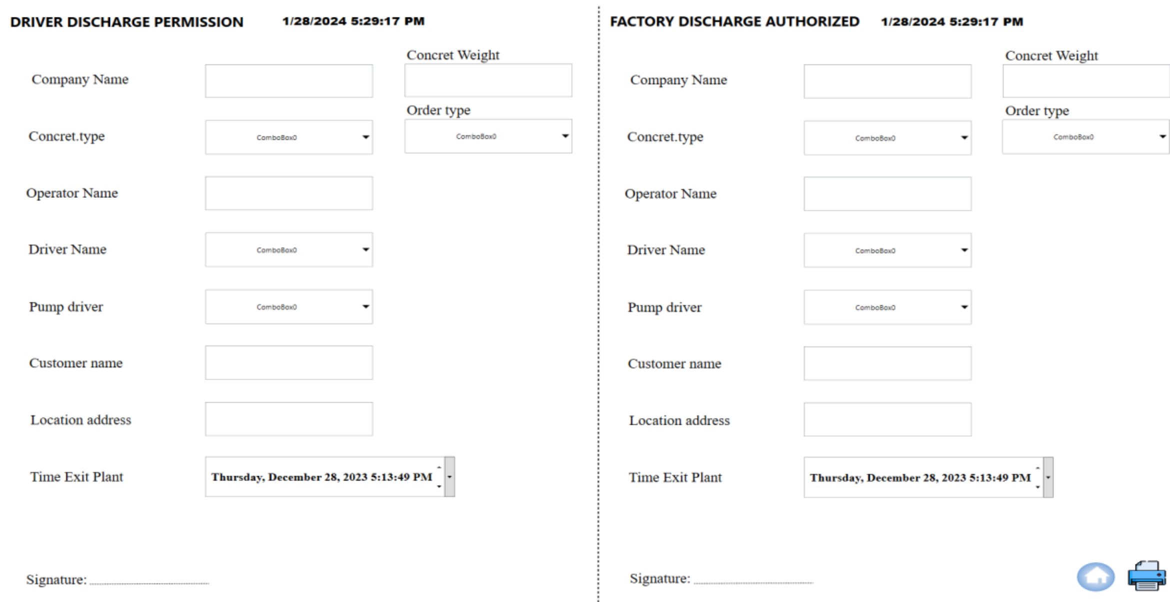


Figure 41:invoice page

➢ Report Page:

Concrete factory reports offer numerous benefits, aiding quality control, performance monitoring, resource management, compliance, cost analysis, and continuous improvement. They are vital for optimizing processes, reducing costs, and ensuring overall business success.

As shown in the figure 42, When entering the report page, this is the factory's page, which contains information about customers' orders, time and date, quantity of water, super quantity, cement quantity.

The amount of sand, quantity of aggregate 1, quantity of aggregate2, quantity of aggregate3, quantity of aggregate4, mixer loading time number one, mixer exit time number one where you can specify the start and end date and time to display the above quantities in the report additionally, the report page allows for the export of data in various file formats such as CSV or Excel, providing flexibility for further analysis or integration with other systems. The interface also supports filtering and sorting options to streamline data retrieval based on specific criteria, enhancing user experience and efficiency. This comprehensive functionality empowers users to gain insights into production metrics and make informed decisions to optimize operations.

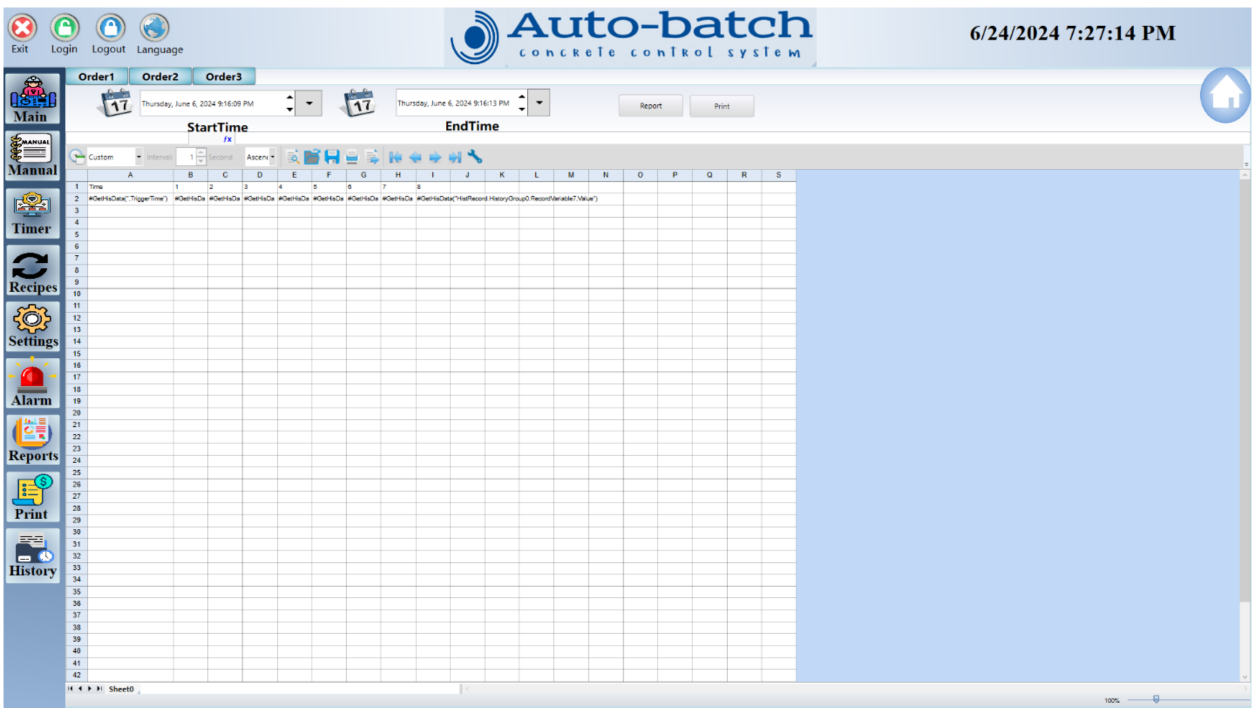


Figure 42:Report Page

➢ Recipes Page:

The mixtures page in a concrete factory is crucial for recipe formulation, quality control, customization, resource optimization, consistency in production, documentation, adaptation to raw material variability, and research and development. It is central to the success and competitiveness of concrete manufacturing. The mixtures page serves as the foundation for creating concrete that meets specific requirements for strength, durability, and other performance characteristics. It allows for precise measurement and combination of raw materials, such as cement, aggregates, and water, to achieve the desired properties in the finished product. Additionally, it enables the monitoring of production parameters to ensure consistent quality and performance of the concrete. as depicted in Figure 43.

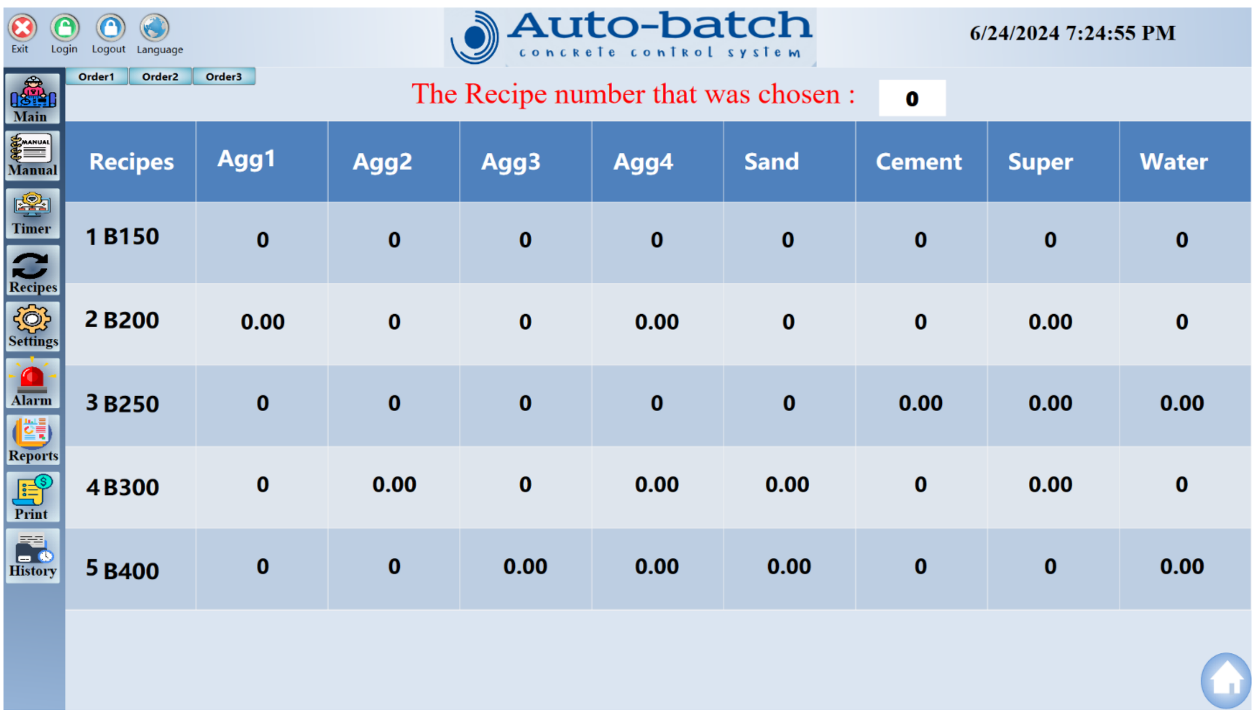


Figure 43:Recipes Page

➢ Timer Page:

On this page, you can adjust the unloading timing of aggregate, water, cement and superplasticizers. In addition, you can adjust the timing of mixing the materials inside the mixer and unloading them into the cement mixture truck, as shown in Figure 44.

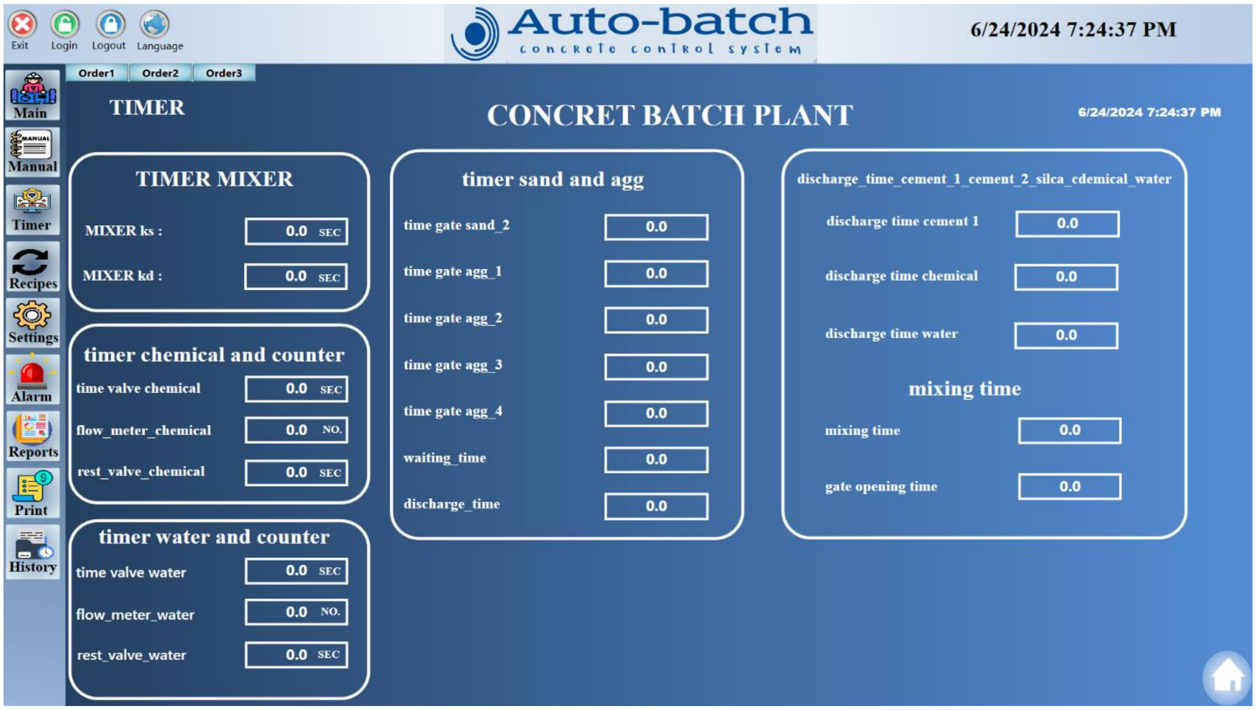


Figure 44:Timer Page

➢ Alarm Page:

Through this page, you can easily identify issues with the conveyor, cement screw, cement pumps, and added chemicals, as well as check the status of water and cement tanks. Additionally, this page aids in streamlining maintenance procedures and promptly pinpointing any potential defects. This innovative solution integrates seamlessly with existing industrial systems, providing real-time monitoring and automatic alert generation for swift action. By centralizing data collection and analysis, it enhances operational efficiency and minimizes downtime, ultimately maximizing productivity and ensuring optimal performance across all components, as shown in Figure 45.

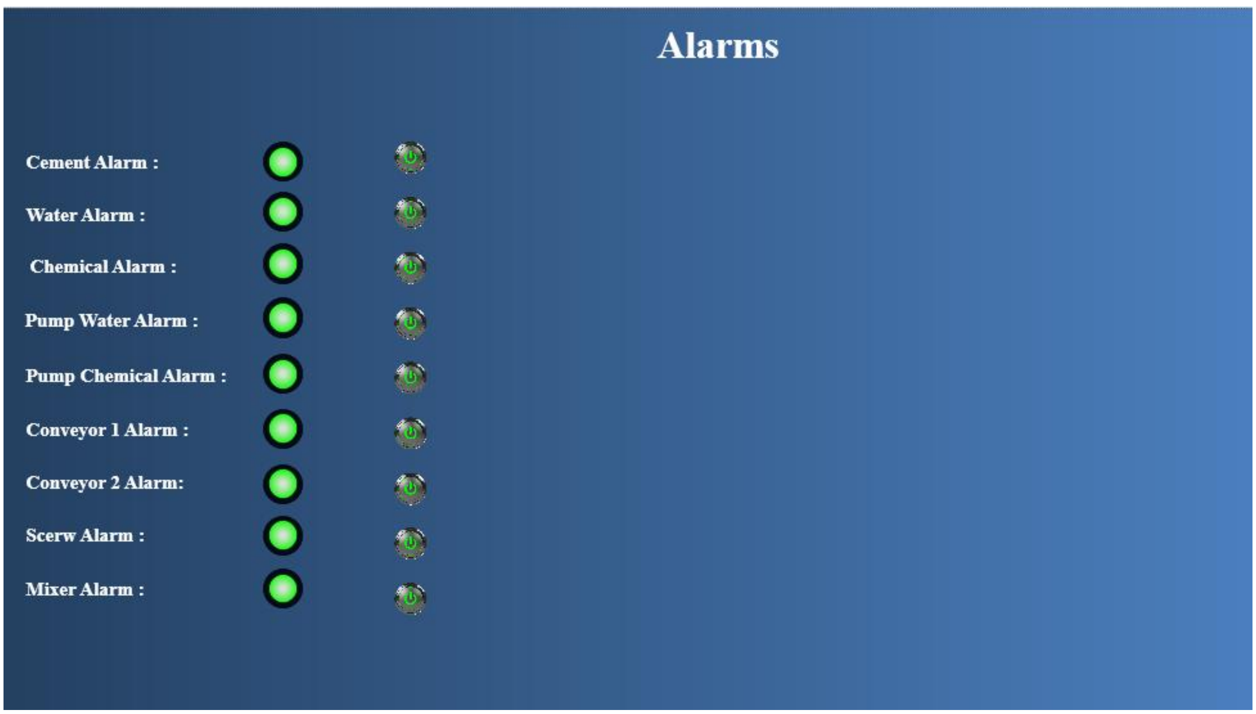


Figure 45:Alarm Page

3.4.3 Selecting a PLC and the selection process:

Based on the prior labor market study and availability of parts and taking into account costs and consultation with Supervisor, a PLC controller from Delta Company was selected from a series suitable for the needs of the project. The virtual system model is built using specific PLC programming, and basic tests are performed to verify its compliance with the project requirements. Successful results were achieved, confirming the accuracy and effectiveness of the controller in managing production processes, making it the ideal choice for project implementation.

The following figure (46) shows how to configure the names of DVP Series Programmable Logic Controllers (MPU), Digital Input/Output (DI/DO) and Analog I/O (AI/AO) and helps in making the correct decisions for the project.

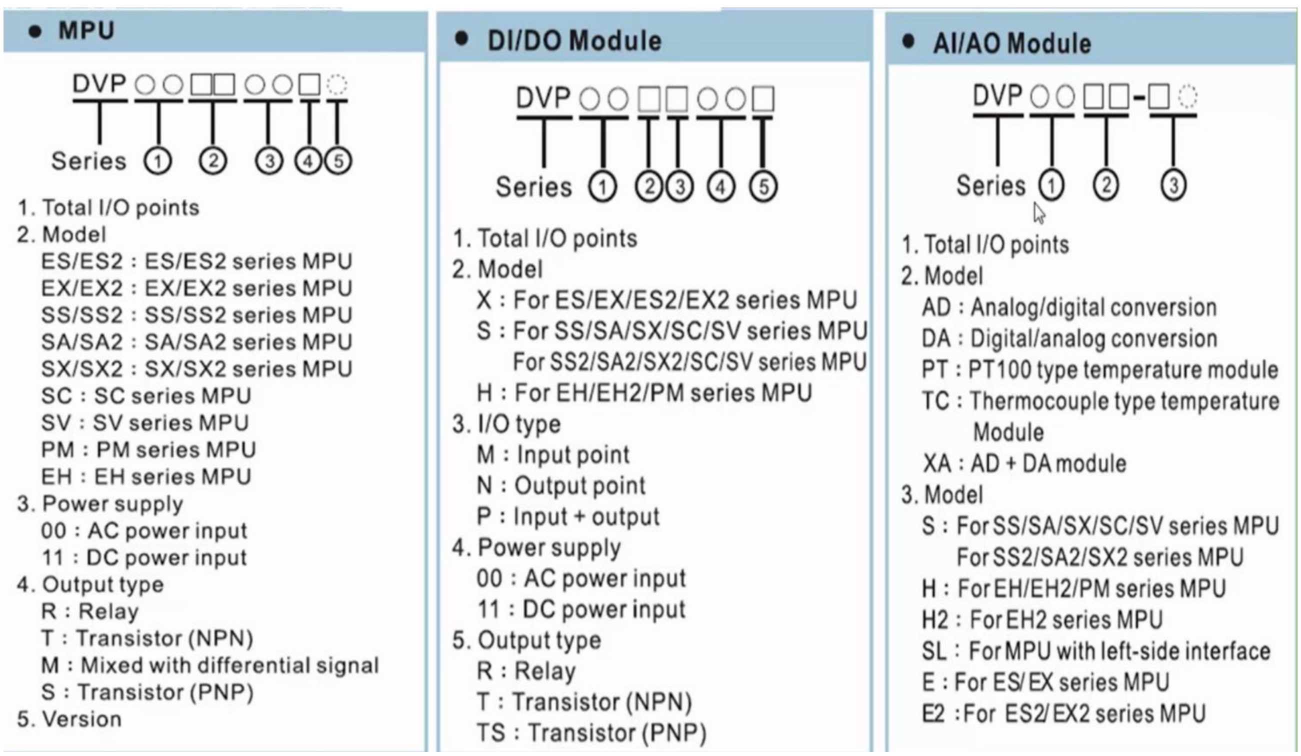


Figure 46:configure the names of DVP Series Programmable

The PLC DVP 14 SS2 was chosen for the project and was programmed using Delta's ISPsoft software. Since the DVP 14 SS2 series PLC offers a versatile range of functions and reliable performance, it was the ideal choice for this project. With Delta's ISPsoft software, the programming process was streamlined and efficient, allowing for seamless integration of various control functions. The user-friendly interface of the software made it easy to program complex logic and ensure smooth operation of the system. as depicted in Figure ().

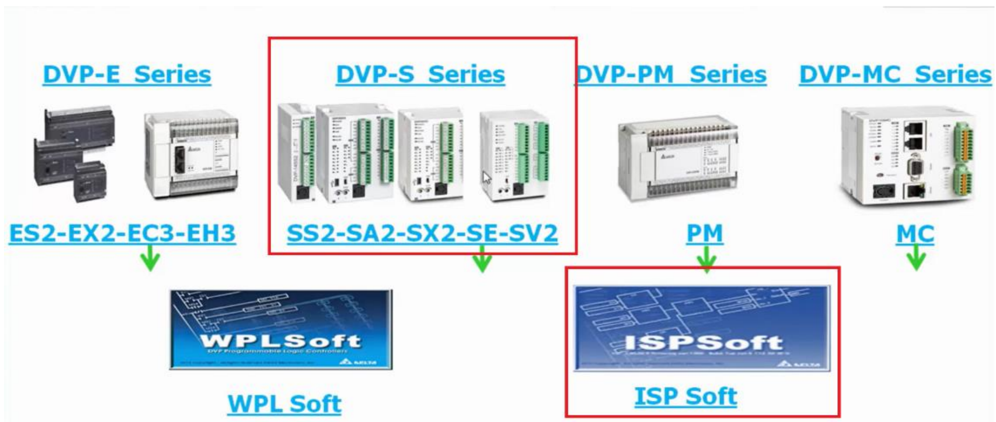


Figure 47:DVP Series and ISP soft program

DVP-14 SS2

Economic and Compact PLC. Max. 480 I/O points:

- Adopts 32-bit CPU
- Program capacity: 8k steps/Data register: 5k words
- Higher execution speed compared to the \ competition: LD: 0.35μς, MOY: 3.4με
- Built-in RS-232 and RS-485 ports (Master/Slave)
- Supports standard MODBUS ASCII/RTU protocol and PLC Link function

Motion Control Functions

- 4 points of 10kHz pulse output
- 8 points of high-speed counters:
- 20kHz/4 points, 10kHz/4 points

Figure 48:PLC DVP-14 SS2

- PLC Wiring:

- The PLC feed is divided into three parts [CPU feed - input units feed - output units feed].

- Powering the CPU requires connecting electricity according to its type, for example, whether it is an alternating or direct voltage, considering the voltage value.

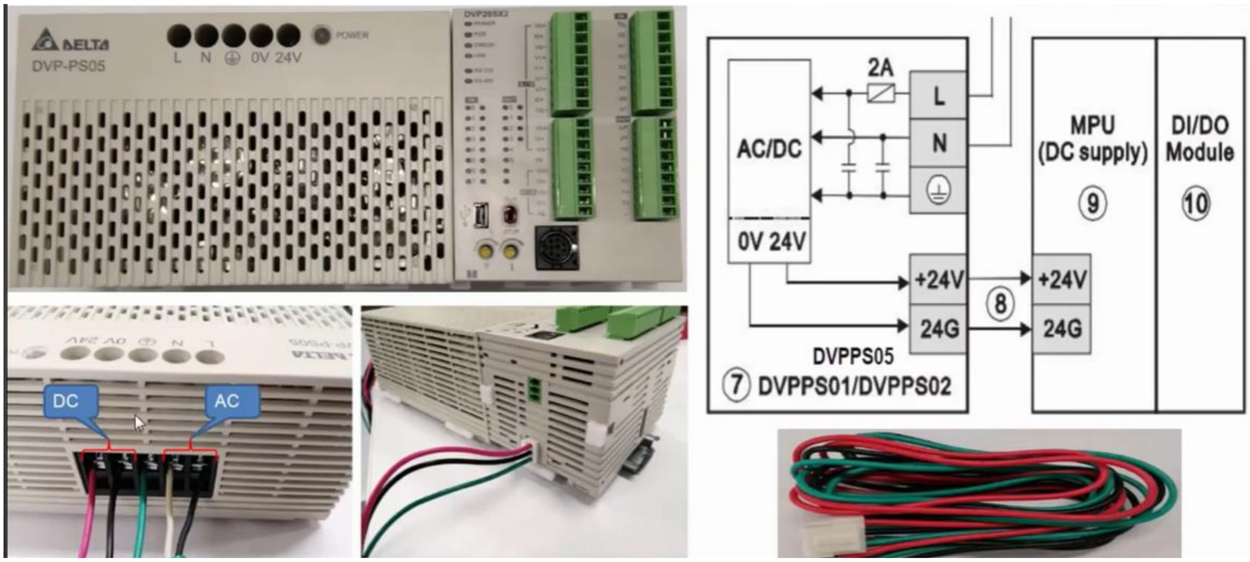


Figure 49:PLC Wiring

➢ Addressing:

Addressing system for PLC inputs and outputs is fundamental to their operation, enabling precise identification and control of various signals. Inputs, typically denoted by X, and outputs, denoted by Y, follow a structured format, facilitating seamless integration and expansion. With digital and analog, I/O options, Delta PLCs cater to diverse automation needs. Understanding the addressing conventions, especially for specialized modules and extensions, is crucial for effective programming and maintenance. This systematic approach ensures efficient data handling, minimizes errors, and enhances overall system performance, making Delta PLCs an indispensable tool in modern industrial settings.

- Inputs:

The following figure(50) shows the number of basic inputs reserved in memory in all PLC Delta companies.

- Digital inputs X0 to X7 ……. X10 to X17(Octal number system)

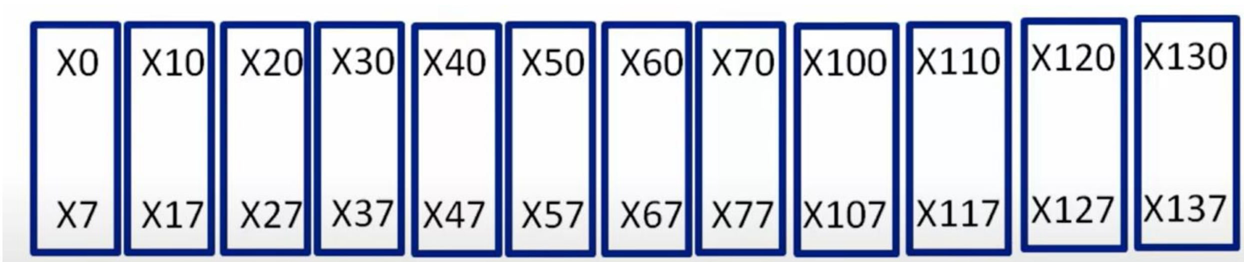


Figure 50:number of basic inputs

- If number of inputs in MPU:
  - ➢ Less than or equal 16

    If all extensions:

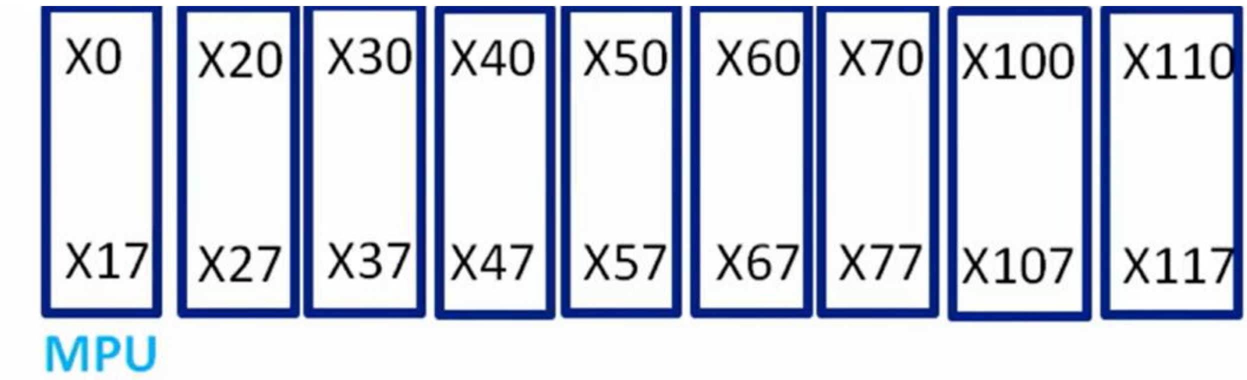


Figure 51:8 input MPU X0 .... X17

If extensions in them 8 input and 16 input:

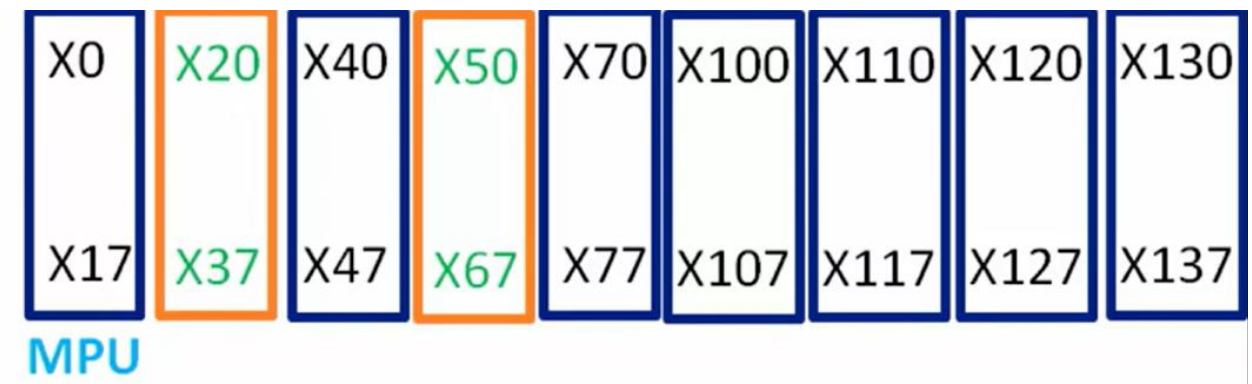


Figure 52:extensions in them 8 input and 16 input

- ➢ Greater than 16

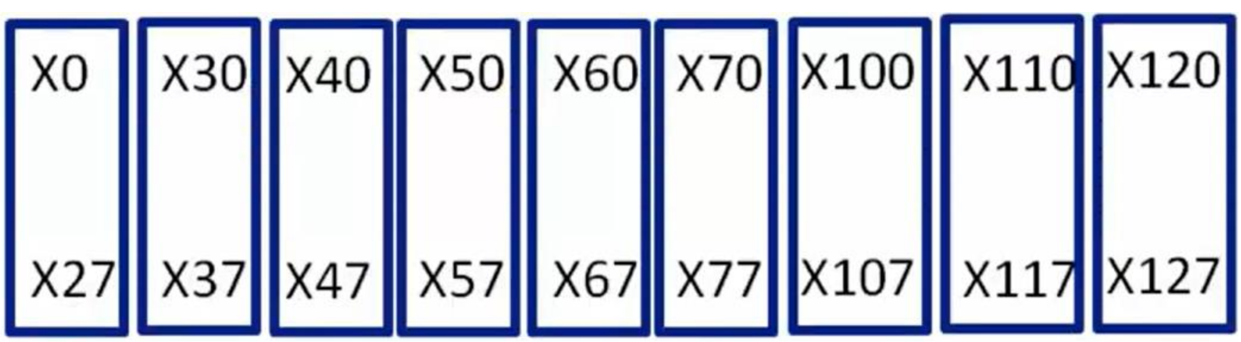


Figure 53:extensions in 16 inputs

- Output:

The following figure (54) shows the number of basic outputs reserved in memory in all PLC Delta companies.

- Digital output Y0 to Y7 ……. Y10 to Y17(Octal number system)

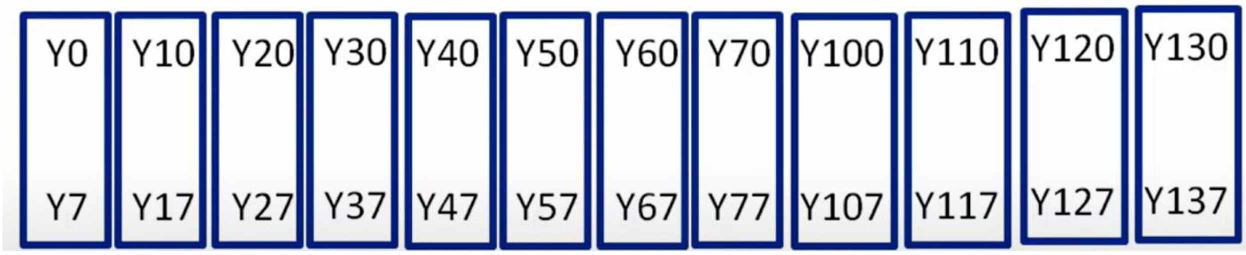


Figure 54:number of basic outputs

- If number of Outputs in MPU:

  - Less than or equal 16

  If all extensions 8 output and MPU Y0 …. Y17:

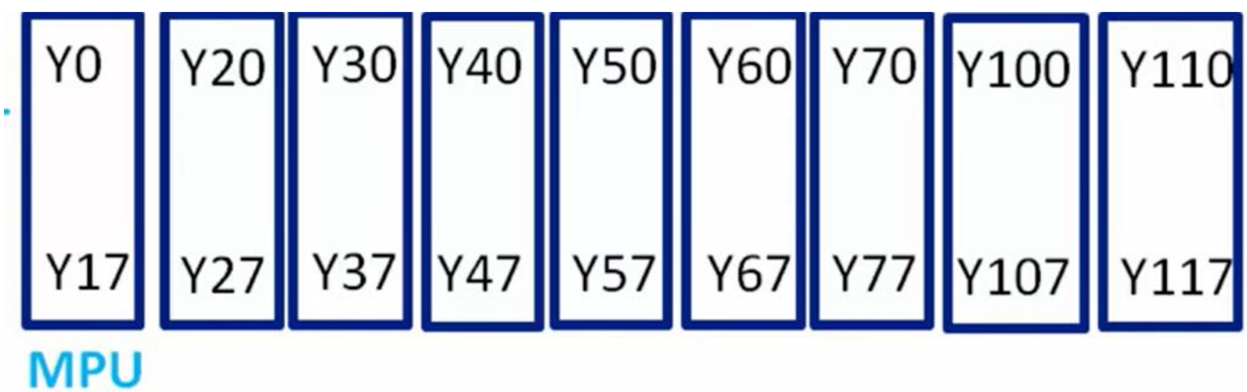


Figure 55:extensions 8 output and MPU Y0 …. Y17

If extensions in them 8 output and 16 output:

Figure 56:extensions in them 8 output and 16 output

- Greater than 16

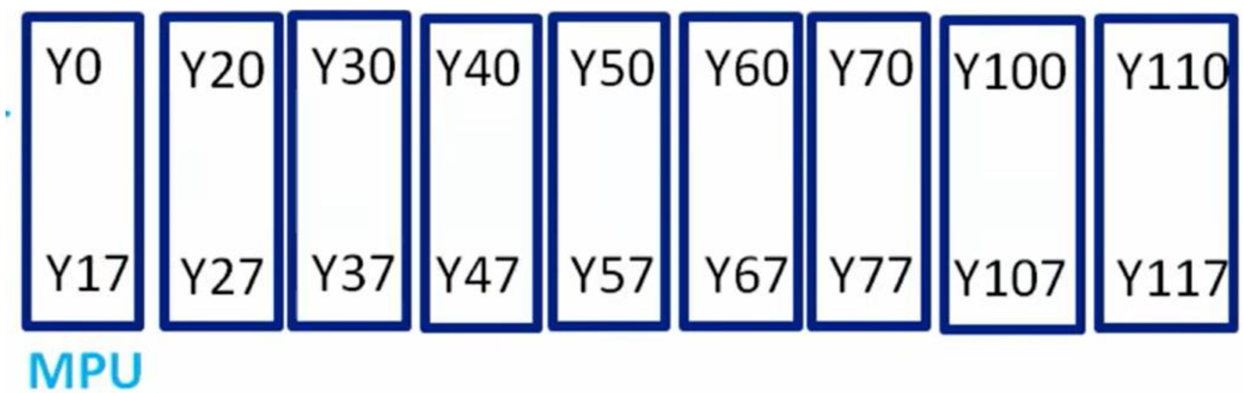


Figure 57:extensions in 16 outputs

- Auxiliary Relay:

- Used only in program starting M0 to Mxxx (Decimal system)

Table 4:Addresses allowed for Auxiliary Relay

M	Auxiliary relay	General	M0~M511, 512 points, (*1) M768~M999, 232 points, (*1) M2000~M2047, 48 points, (*1)	Total 4096 points
		Latched	M512~M767, 256 points, (*2) M2048~M4095, 2048 points, (*2)	
		Special	M1000~M1999, 1000 points, some are latched	

1. General: It does not maintain its state when the power supply.
2. Latched: It retains its state during power outages and returns to its initial state when reset.
3. Special: It has a specific function that can be used within the program. As shown in the table 5 that.

Table 5: Special Auxiliary Relay

Special M	Function	OFF ⇩ ON	STOP ⇩ RUN	RUN ⇩ STOP	Attrib.	Latch-ed	Default
M1000*	Monitor normally open contact	OFF	ON	OFF	R	NO	OFF
M1001*	Monitor normally closed contact	ON	OFF	ON	R	NO	ON
M1002*	Enable single positive pulse at the moment when RUN is activate (Normally OFF)	OFF	ON	OFF	R	NO	OFF
M1003*	Enable single negative pulse at the moment when RUN is activate (Normally ON)	ON	OFF	ON	R	NO	ON
M1004*	ON when syntax errors occur	OFF	OFF	-	R	NO	OFF
M1008*	Watchdog timer (ON: PLC WDT time out)	OFF	OFF	-	R	NO	OFF
M1009	Indicate LV signal due to 24VDC insufficiency	OFF	-	-	R	NO	OFF
M1011*	10ms clock pulse, 5ms ON/5ms OFF	OFF	-	-	R	NO	OFF
M1012*	100ms clock pulse, 50ms ON / 50ms OFF	OFF	-	-	R	NO	OFF
M1013*	1s clock pulse, 0.5s ON / 0.5s OFF	OFF	-	-	R	NO	OFF

- ➢ Data Register:

- Used to store data starting from D0 to Dxxx (Decimal system)

Table 6:Addresses allowed for Data Register

Data register	General	D0~D407, 408 words, (*1) D600~D999, 400 words, (*1) D3920~D4999, 1080 words, (*1)	Total 5000 points
	Latched	D408~D599, 192 words, (*2) D2000~D3919, 1920 words, (*2)	
	Special	D1000~D1999, 1000 words, some are latched	
	Index	E0~E7, F0~F7, 16 words, (*1)	

The size of data registers in a PLC can vary depending on the specific model and manufacturer. In general, data registers in PLCs, including those from Delta Electronics, typically have the following characteristics:

- Common Sizes of Data Registers
    1. 16-bit Registers (Word):

Most data registers in PLCs are 16-bit, meaning they can store an integer value ranging from 0 to 65535 (unsigned) or -32768 to 32767 (signed).

These are sufficient for many typical control and automation tasks.

2. 32-bit Registers (DWord):

Some PLCs also support 32-bit registers for applications requiring larger numerical values or more precision. These registers can store values from 0 to 4,294,967,295 (unsigned) or -2,147,483,648 to 2,147,483,647 (signed).

They are used for more complex calculations or where larger ranges are needed, such as in advanced data logging or higher precision control.

Connecting Extension Modules to Delta PLCs:

extension modules are used with PLCs to extend input and output capabilities beyond what is available in the main unit. These units can include additional digital inputs and outputs, analog inputs and outputs, and specialized functions such as communication ports. Extension units can be networked on the right or on the left, Specialized I/O Modules, Function Modules, Safety Modules, Analog Signal Processing Modules, if ends with "SL" it connects in the PLC from the left; if it ends with "S" it connects in the PLC from the right. As in the following figures 58, 59, 60, 61 and 62 .

Figure 58 :Connecting Extension Modules to Delta PLCs

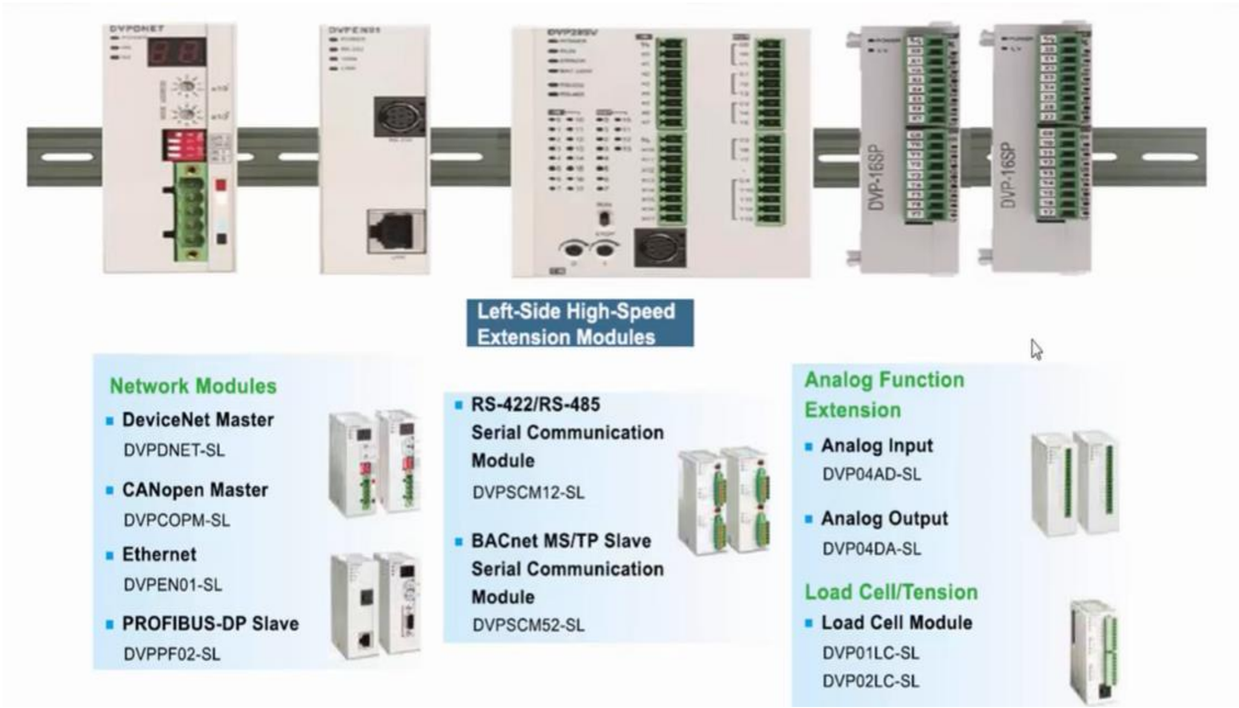


Figure 59:left-side High-speed Extension Modules

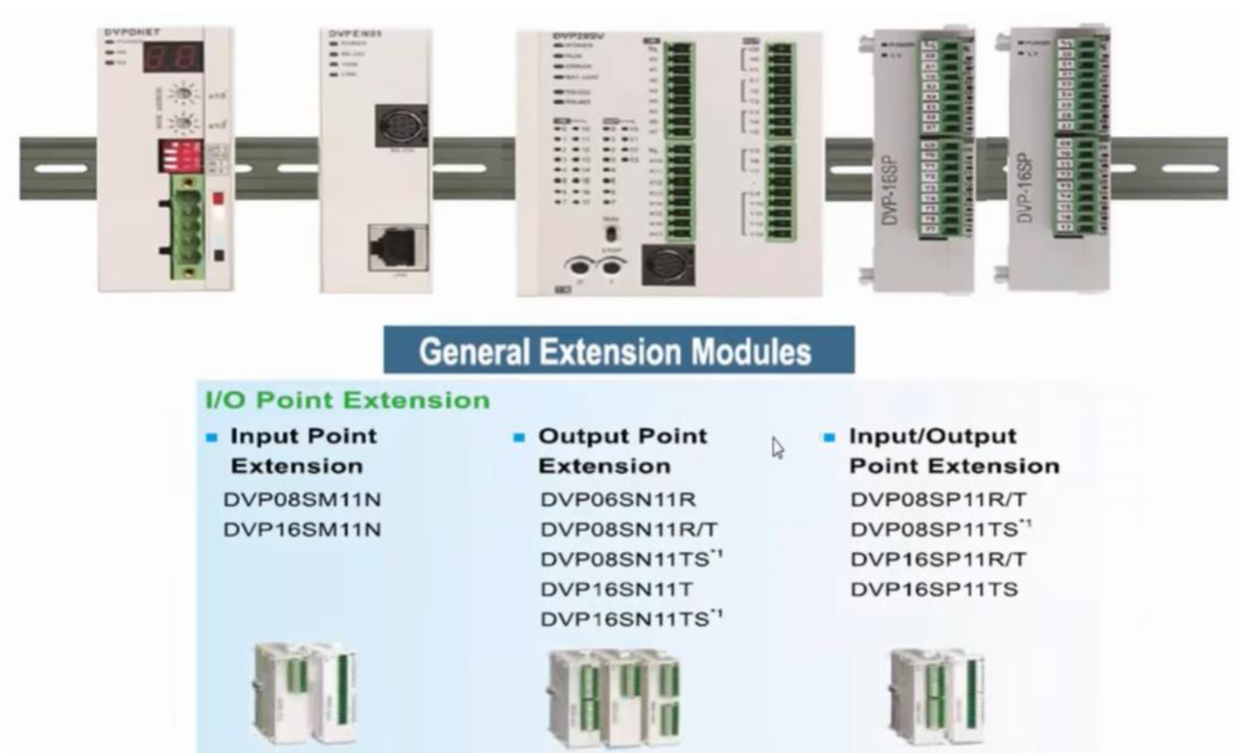


Figure 60: I/O Extension

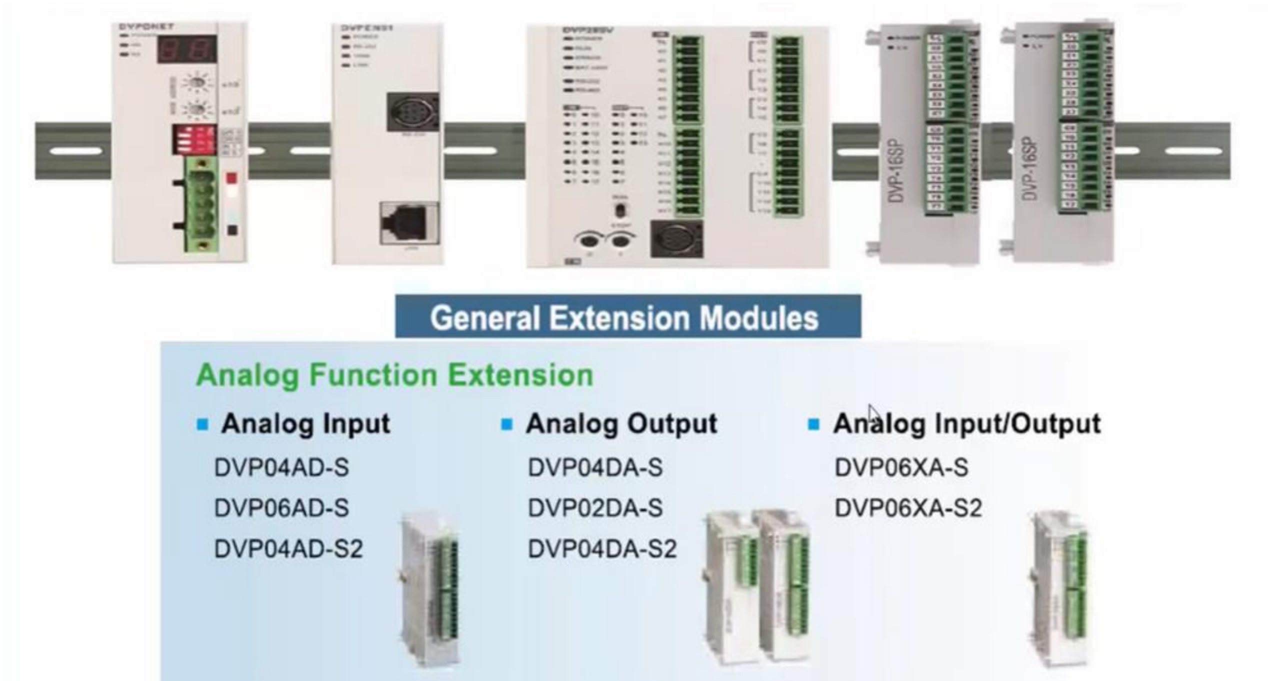


Figure 61:I/O Analog Extension

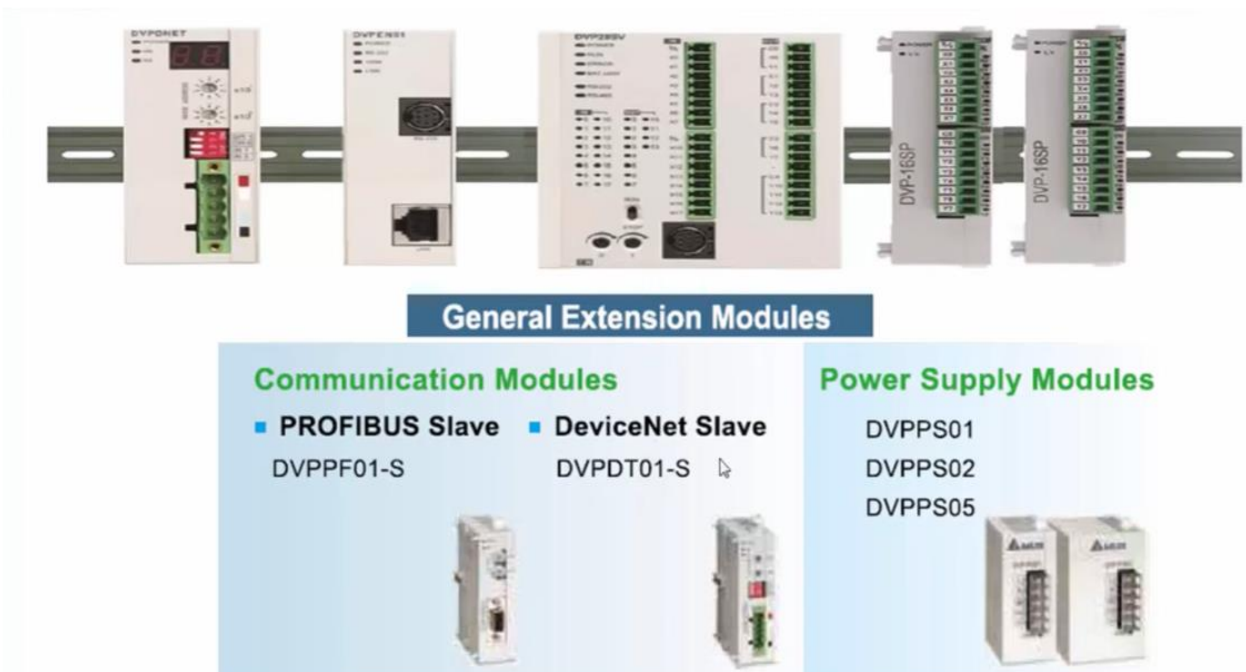


Figure 62: communication and Power Supply Modules

the maximum number of extension modules that can be connected to a Delta PLC varies by model. For the DVP series, the number can range from 8 to 16 modules, depending on the specific PLC model. Always refer to the technical specifications and manuals for your specific PLC model to determine the exact limitations and ensure proper configuration and power supply arrangements.

Figure 63:maximum number of extension modules

3.4.4 Serial communications

There are many types and protocols for serial communications, such as:

- RS -232: It is the oldest type of serial communication, but it has existed until now and we use it, and it can continue for a long time.
- RS-422/RS-485: It is considered newer than the 232-RS and is built in with most types of PLC or other peripheral devices without adding any module. They are considered faster than the 232-RS and we will talk about their advantages and disadvantages in detail.
- CAN.
- Ethernet.
- USB.
- HDMI.

RS-232

- The RS-232 serial communication is considered one of the oldest serial communications, as it was introduced in late 1962. This type allows communication between two points only, point to point, the first being a sender and the other being a receiver.
- This connection can be simplex or full duplex
- Reception sensitivity is ∓3 Volts
- . Logical levels are 15 to 5
- . One of the disadvantages of this communication style is that the maximum length of the communication cable is 20 meters.
- The maximum connection speed or data transmission speed is 20 Kbits/s

- The connection method is single ended
  That is, we have two parties, the first to which we send data, while the second party is the receiver from which we will take data for the landline, meaning the GND line must be connected to the connection.

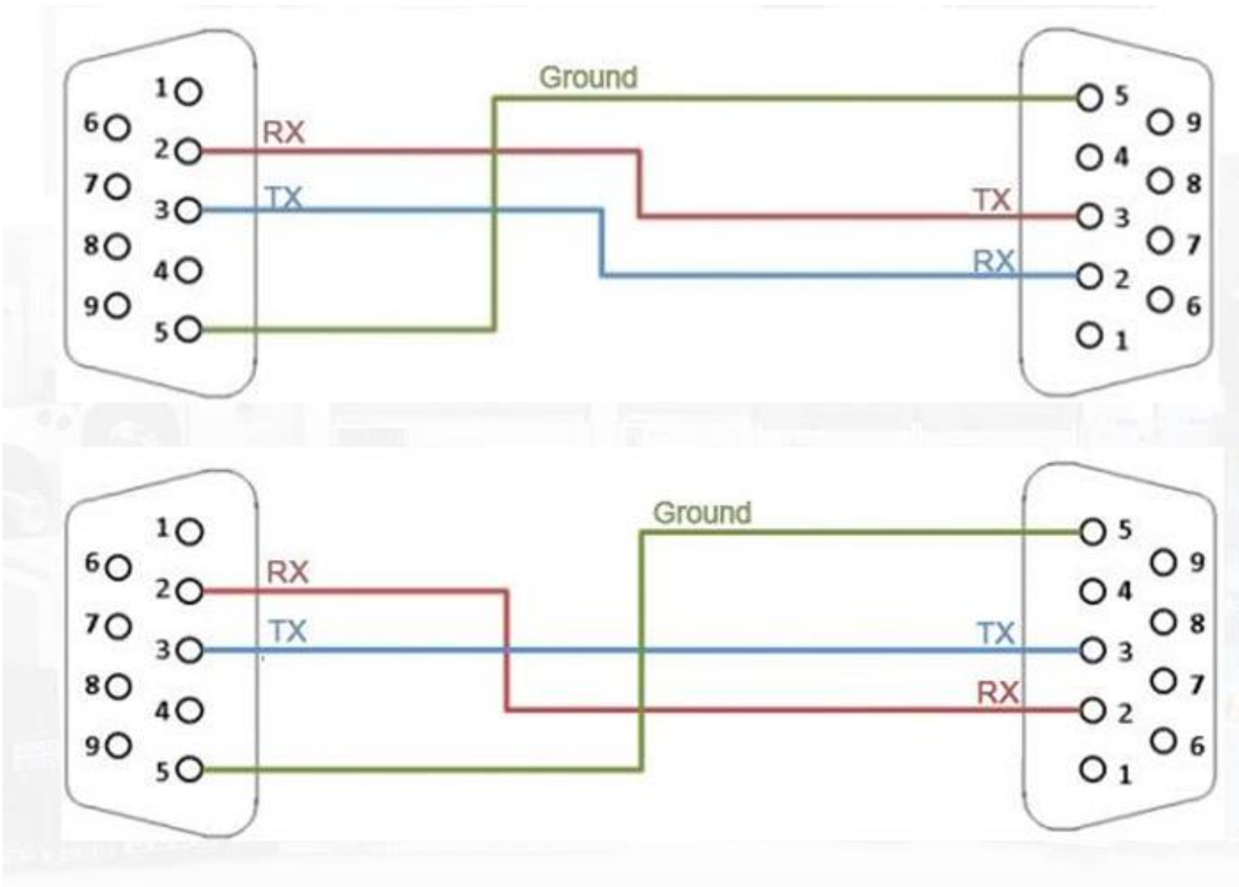


Figure 64:connection RS-232

RS-485:

- This connection works with the Master Slave system, meaning that it will not be Point to Point as we saw in the RS-232, meaning this connection will allow us to form a network. The maximum number of Master will be 32 devices and the maximum number of Slave or Receiver will be 32, but on the condition that there is one device on bus communication at the same time, one driver on the bus, that is, if there is more than one sender, for example, and the first sender has finished sending his message to the future, he must exit the bus for the second sender to enter, and so on. Of course, programmatically, there must be a time limit to address the peripheral devices connected to the communication bus, and not It is permissible to address all devices at the same time.

- This type of connection allows us to increase the number of Slaves to 254 receivers, but we must add an RS-485 repeater such as the Delta IFD8510, as each repeater supports a specific group of Slaves.

- The RS-485 is considered a HALFDUPLEX connection, meaning it is not permissible to send and receive at the same time. That is, first we send the data and then we receive it.
- The connection for the 485-RS is considered a differential connection, meaning:

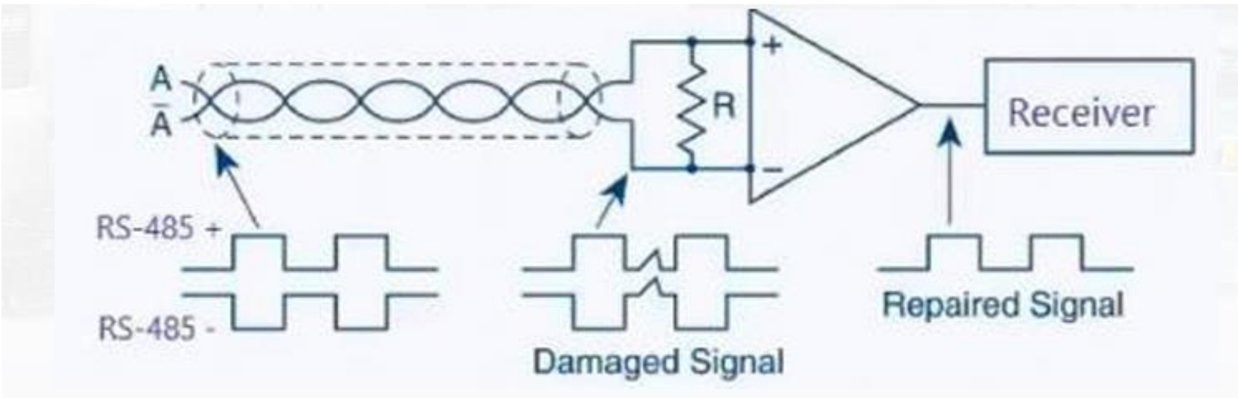


Figure 65:differential connection

- The comparator compares the two input signals on the positive pole and the negative pole. In the normal state, there is always a signal equal to and opposite to the signal on the positive pole in the negative pole. Therefore, the output of the analogue comparator is a logical 1. However, when a noise signal arrives, it will affect both the reflective and non-reflective inputs with the same value. Then the comparator outputs a logical 0 and deletes the incoming noise signal. In this process, we have eliminated Noise cancellation.

- The reception sensitivity is 200, that is, from zero until this value, the receiver will delete it, considering it a interference signal.
- Logic levels are (∓1.5 to ∓6)V.
- The maximum length of the communication cable is 1200 meters, of course, with the possibility of increasing the distance by using signal repeaters.
- The highest rate and speed of sending data is 50 Mbits/s.

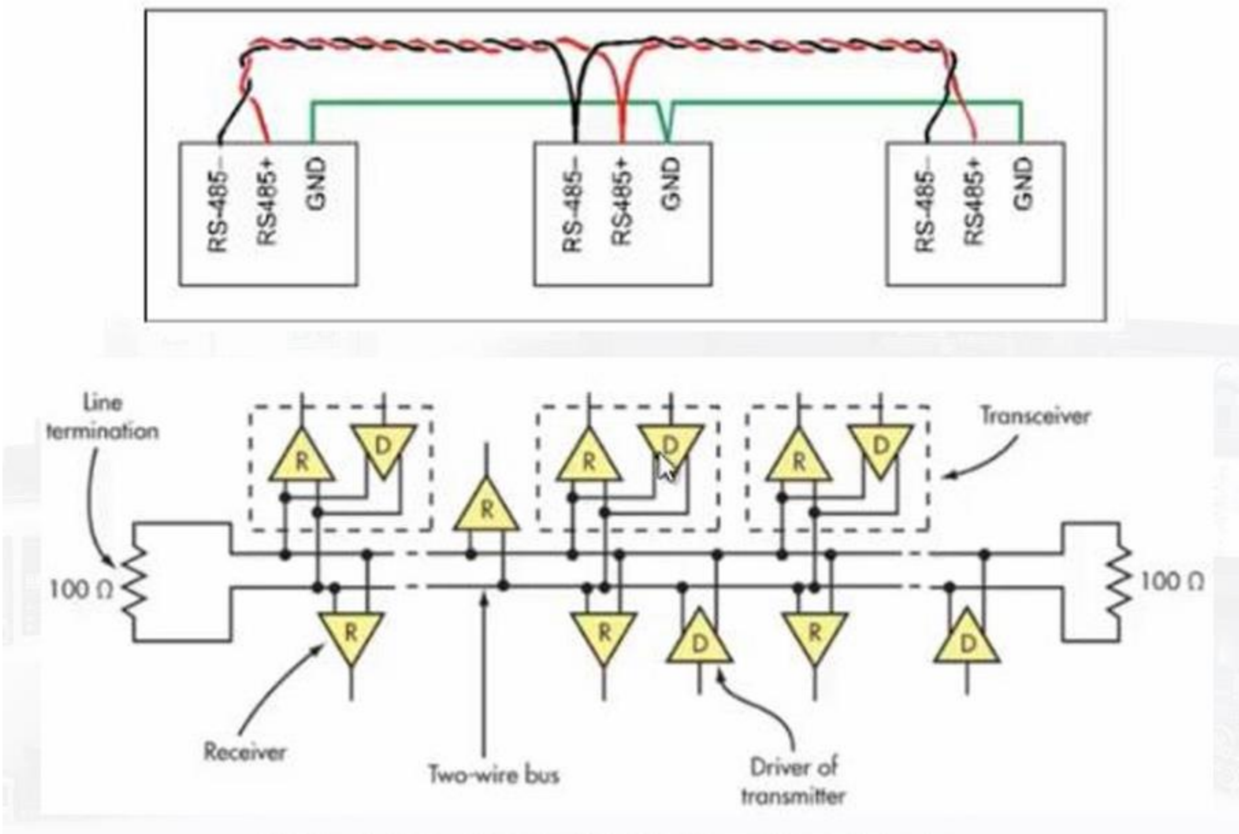


Figure 66::connection RS-485

→Disadvantages of RS -485 contact:

The maximum number of receiving devices is 32, and of course we said that the Bus problem can be solved on the repeater by adding.

- The total permissible distance of the communication cable is 1200 meters, but it can be solved by adding a repeater because it will amplify the signal again, allowing it to be transmitted to another 1200 meters, or according to the specifications of the repeater itself.
- The appearance of parasitic capacitances along the line for long distances is because the communication wire is made up of two lines with electrical voltage signals passing through them and an insulator between them. That is, we now have a parasitic capacitance that can cause signal errors and reflected waves. To avoid these capacitances, a resistance must be installed at the beginning and end of the line called Line. termination value is about 120Ω.
- The type of cable that should be used over long distances to avoid noise signals must be shielded, twisted pair.

- Modbus communication technology

Let us learn about some of the terms that we may encounter while dealing with this communication:

- Modbus: It is a serial communication protocol developed by Medicon, currently a Schneider company, for serial communication between PLC units and field devices in their various forms. It was published and applied in 1979.

- The word communication protocol means the language that the field devices speak and understand. For example, we have an HMI and an inverter, each of which supports RS-485 Modbus RS technology. Then both devices can communicate with each other and send and receive data between them. Suppose we have two other devices, one of which supports Modbus and the other. It supports Profinet, so it is not possible to communicate between them because there is no unified protocol or language between them, and so on......

- Slave ID: Every Field device present with us on the network, that is, on the communication line, must have a specific number or what is called the ID from 1 to 254. The ID is like the device's personal card, as each Master has an ID that equals zero (ID=0). Slaves from 1 to 254.
- Function Code: It is a specific code that is included in the message sent from Master to the Slave in order to determine the function that the Slave must perform whether reading or information about a specific case.

- Parity Bit: It is a bit in the message to detect errors. It is placed at the beginning of the string of numbers to be sent to determine whether the number of units (1-bits) in the string is even or odd. It comes in two types, "Even" and "Odd," and its value must be identical between the senders. And the future.

- Stop bit: It is called the breathtaking bit, meaning it is a bit that gives a distance or time interval between sending each message and another message, and it does not have a value of either one or zero. Usually, we increase the stop bit as the speed of sending data increases, so it is (0,1,1.5,2).

- Sometimes we encounter a problem while sending and receiving data, even though the settings of the sender and receiver are equal, then we need to increase the stop bit value a little.

- Baud Rate: It is the speed of data transfer between the sender and the receiver and is estimated at bits/s from 110 to115200 bits/s.
- RTU mode (Remote Terminal Unit): It's one of the patterns he's working on Modbus communication.
- ASCII Mode (American standard for information): It is the second style that the Modbus communication.
- CRC: It is a message error checking system used with the RTU.
- LRC: It is a message error checking system used with the ASCII.

The difference between RTU and ASCII communication modes:

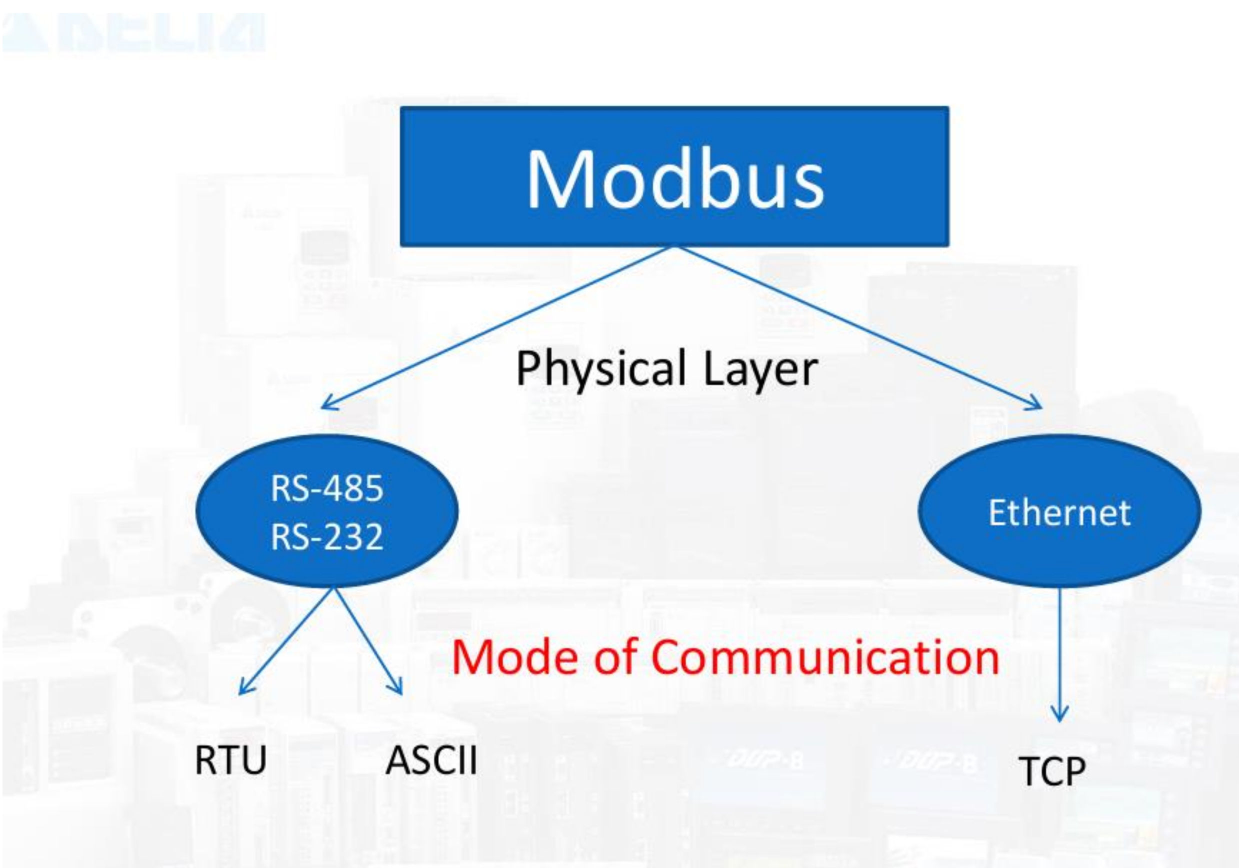


Figure 67:Modbus of Communication

- The difference is in the form of the message sent from the sender to the receiver. In the RTU mode, the message form is composed of units and zeros only, while in the ASCII system the message form is composed of units, zeros, and characters. so, what is the advantage of each of the two modes:
- In the RTU mode, more data is sent in the message than in the ASCII mode at the same data transmission speed, but the error rate may be greater than in the ASCII mode.

- As for ASCII mode, considering that the message contains letters and numbers, the message will be clearer to the recipient and easier to interpret, meaning that the error rate is lower than that of RTU. The only drawback is that it will not give the amount of data that RTU gives at the same Baud rate.

- In short, there is no difference for us in both modes because we will be governed by the device installed on the Modbus, whether it supports RTU, ASCII, or both.

- When establishing a connection, all existing devices must speak the same mode, either RTU or ASCII.
- Format of the message sent via Modbus:
    - First, the message consists of two parts. The first part is called the Query message and is sent from the Master to the Slave.
    - Secondly, the second part of the message is called the response message and is sent From Slave to Master and is equal to the Query message

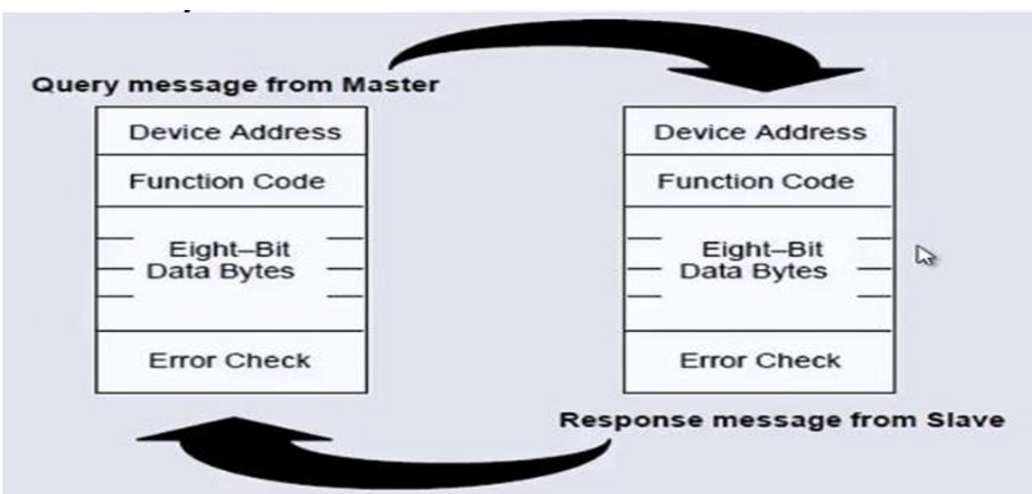
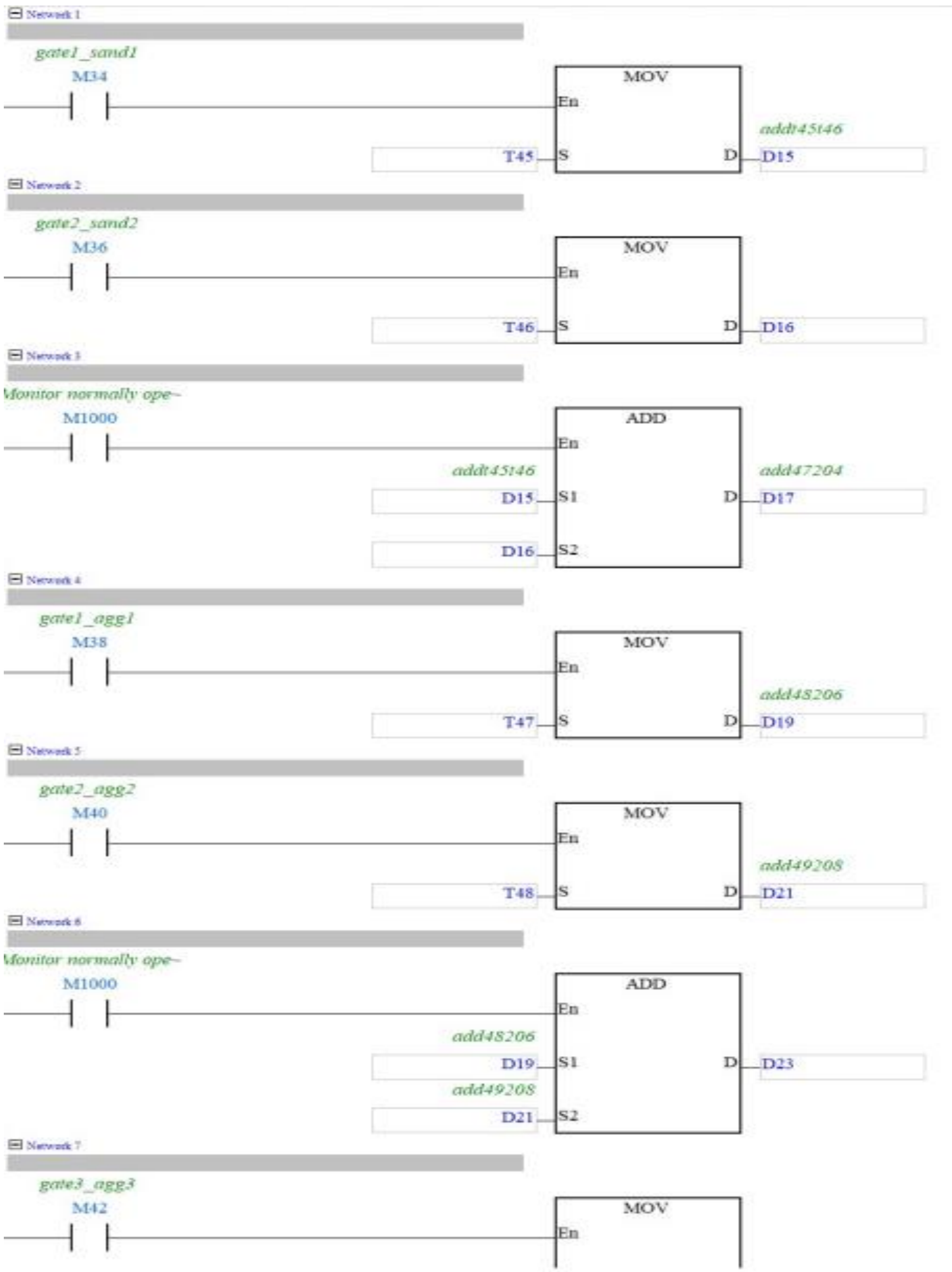
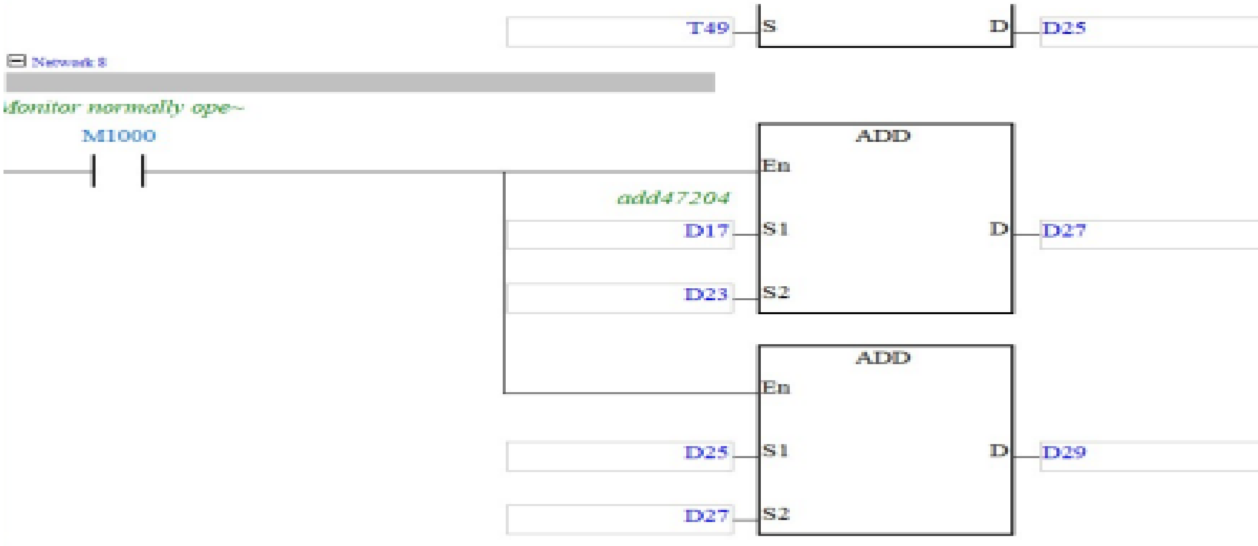


Figure 68: message sent via Modbus

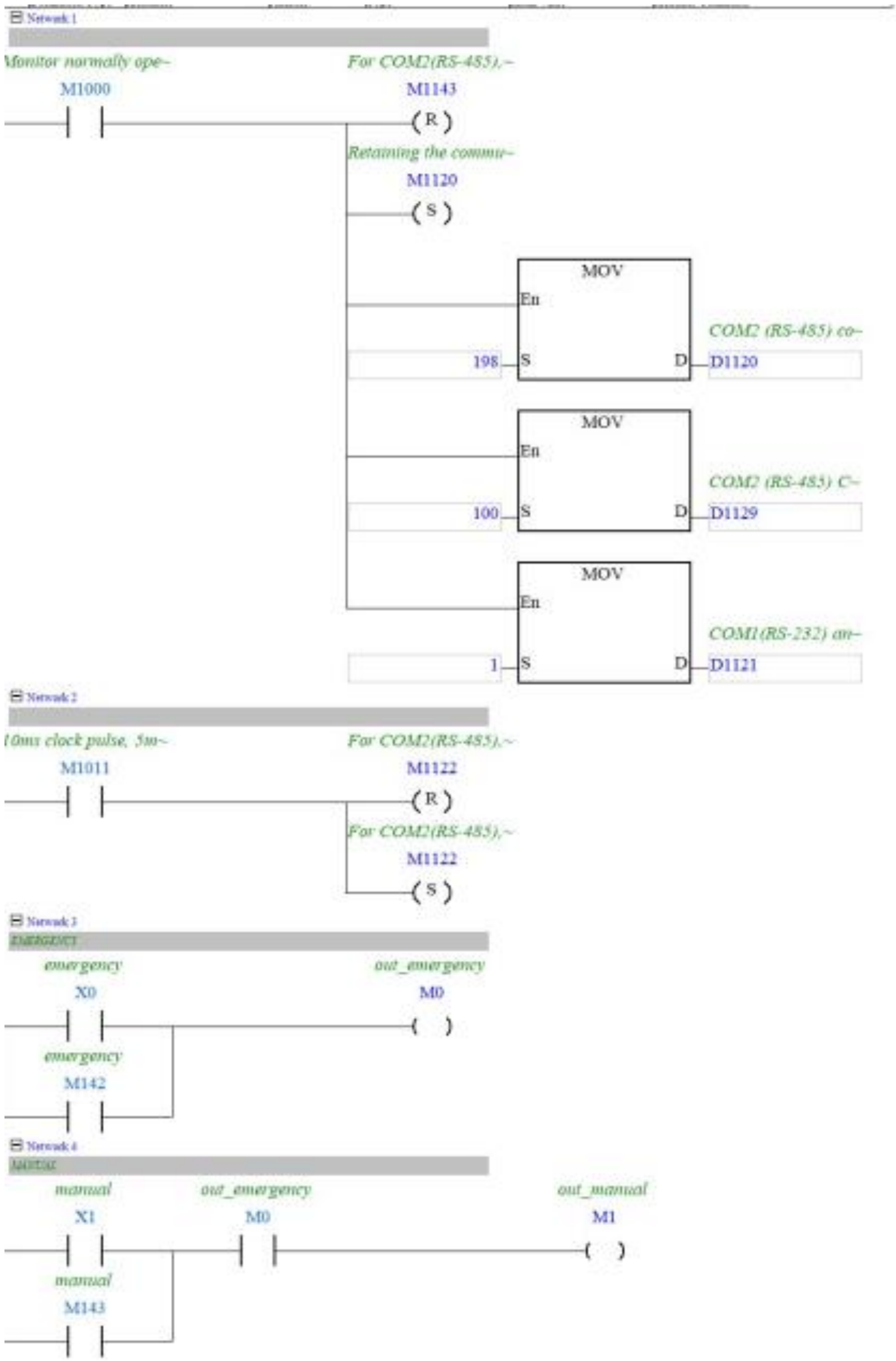
3.4.5 PLC programming using ISPsoft program:

In this section of the project, we will showcase a segment of the PLC programming that was created using the Ladder Diagram, as depicted in the subsequent figures.

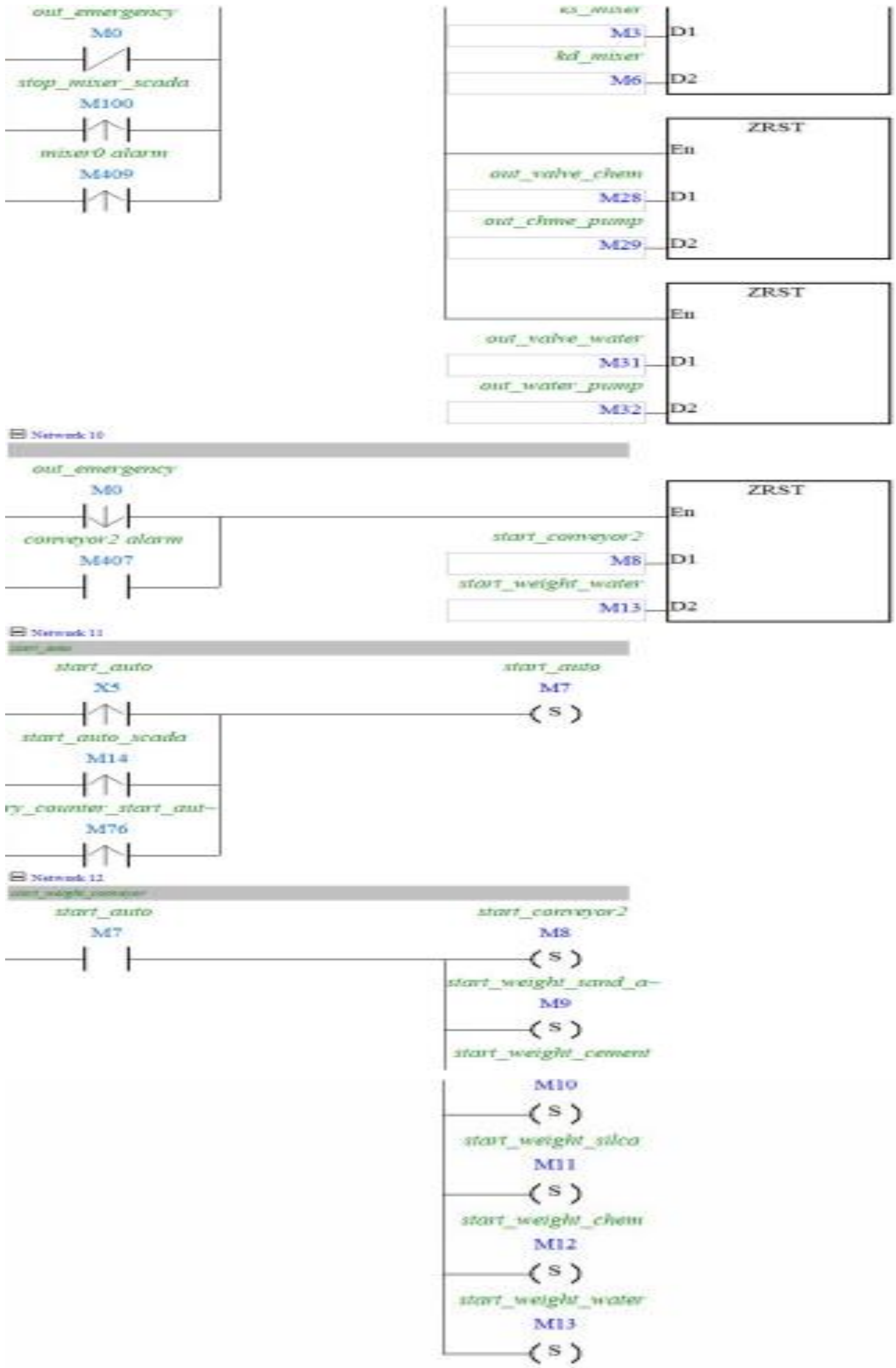


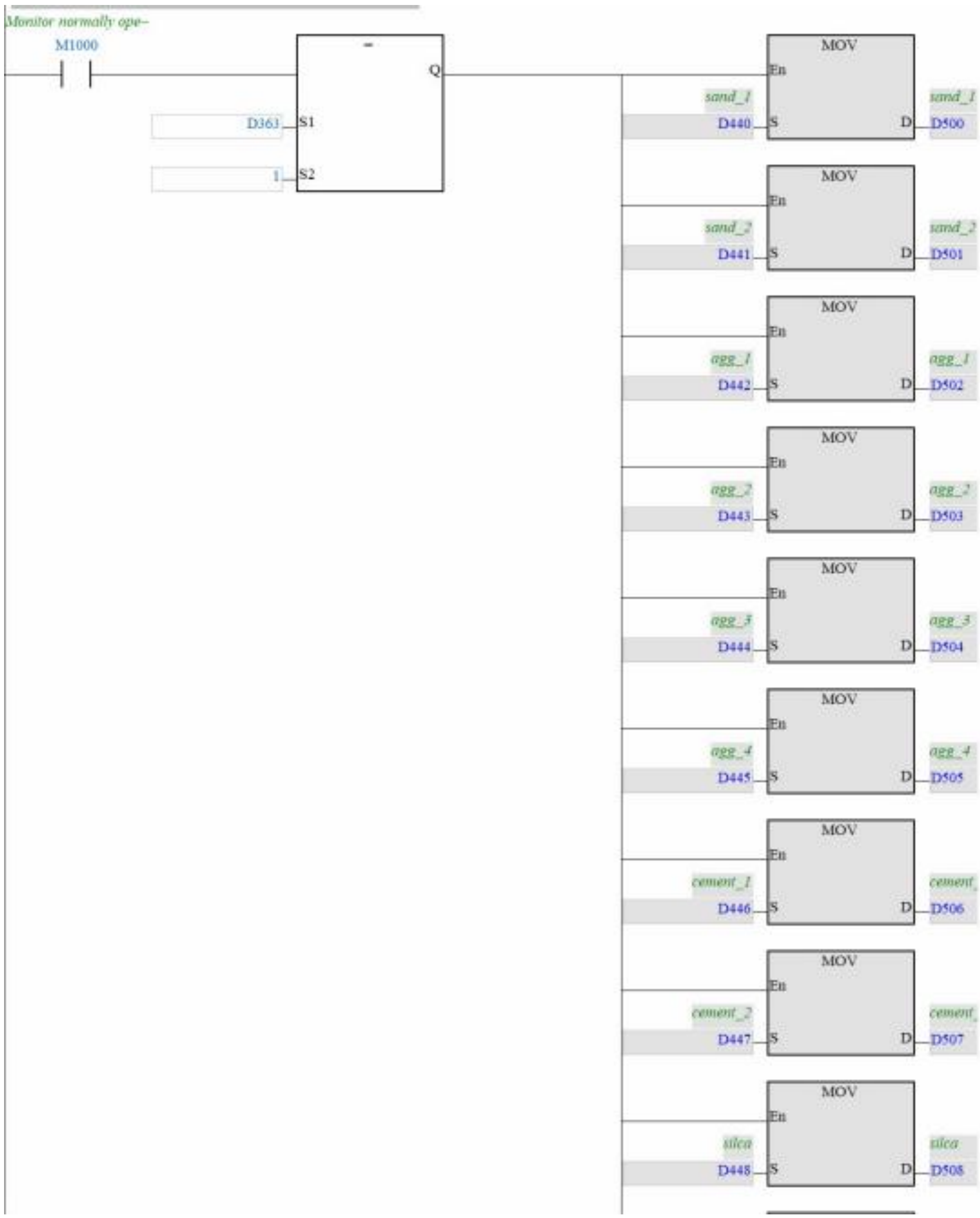


T49
S
D
D25
Network 8
M1000
ADD
En
add47204
D17
S1
D
D27
D23
S2
ADD
En
D25
S1
D
D29
D27
S2



Monitor normally ope~
M1000
For COM2(RS-485),~
M1143
R
Retaining the commu~
M1120
S
MOV
En
198
S
D
COM2 (RS-485) co~
D1120
MOV
En
100
S
D
COM2 (RS-485) C~
D1129
MOV
En
1
S
D
COM1(RS-232) an~
D1121
10ms clock pulse, 5m~
M1011
For COM2(RS-485),~
M1122
R
For COM2(RS-485),~
M1122
S
emergency
X0
out_emergency
M0
emergency
M142
manual
X1
out_emergency
M0
out_manual
M1
manual
M143


out_emergency
M0
stop_mixer_scada
M100
mixer0 alarm
M409
ks_mixer
M3
D1
kd_mixer
M6
D2
ZRST
En
out_valve_chem
M28
D1
out_chme_pump
M29
D2
ZRST
En
out_valve_water
M31
D1
out_water_pump
M32
D2
Network 10
out_emergency
M0
conveyor2 alarm
M407
ZRST
En
start_conveyor2
M8
D1
start_weight_water
M13
D2
Network 11
start_auto
X5
start_auto_scada
M14
M76
start_auto
M7
S
Network 12
start_auto
M7
start_conveyor2
M8
S
M9
S
start_weight_cement
M10
S
start_weight_silca
M11
S
start_weight_chem
M12
S
start_weight_water
M13
S


Monitor normally ope-
M1000
=
Q
D363 S1
1 S2
MOV
En
sand_1
D440 S
D
sand_1
D500
MOV
En
sand_2
D441 S
D
sand_2
D501
MOV
En
agg_1
D442 S
D
agg_1
D502
MOV
En
agg_2
D443 S
D
agg_2
D503
MOV
En
agg_3
D444 S
D
agg_3
D504
MOV
En
agg_4
D445 S
D
agg_4
D505
MOV
En
cement_1
D446 S
D
cement_
D506
MOV
En
cement_2
D447 S
D
cement_
D507
MOV
En
silca
D448 S
D
silca
D508

→After deep research and study of the labor market, we found that the best type of PLC that can be chosen to network and design a concrete system in a realistic way, achieving the best productivity and quality of concrete at the lowest costs, is the DVP 28SV2 PLC. It should be networked with a special electrical panel consisting of breakers, relays, overload protection, sockets, and a power supply, as shown in the following figures [69,70,71 and 72].

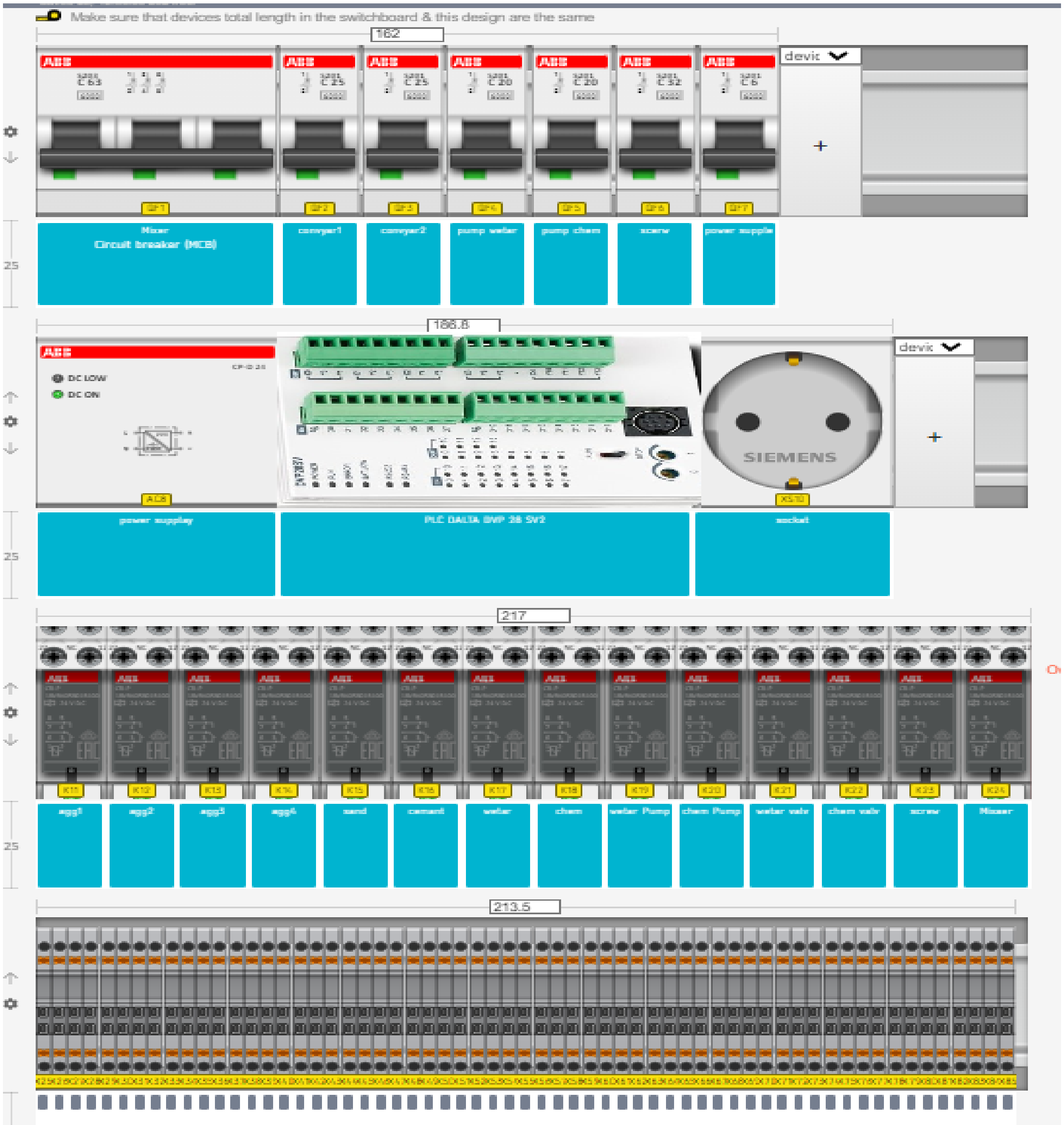


Figure 69: distribution board the PLC, Relays and C.B

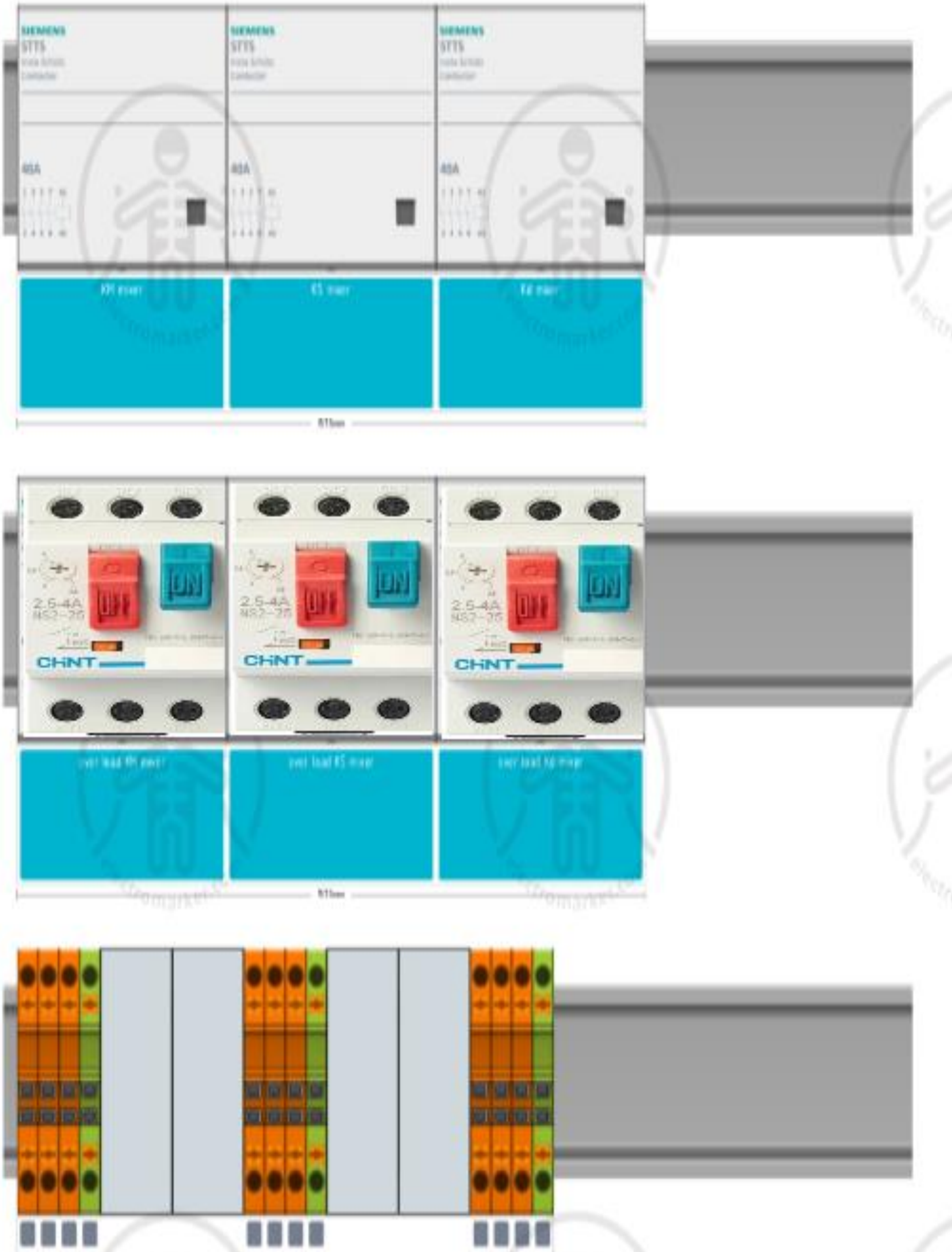


Figure 70:distribution board the mixer (contactor and over load)

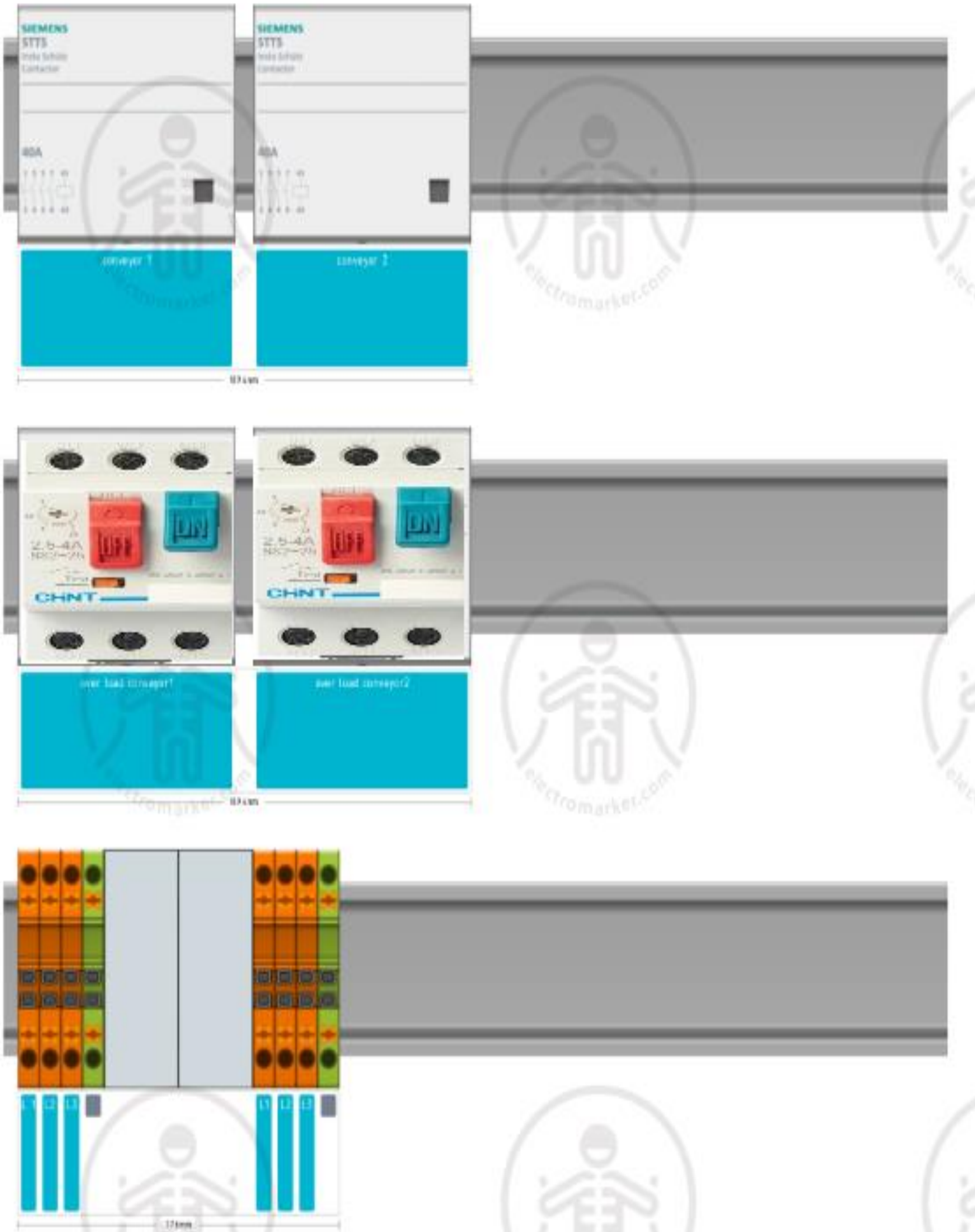


Figure 71:distribution board the conveyor (contactor and overload)

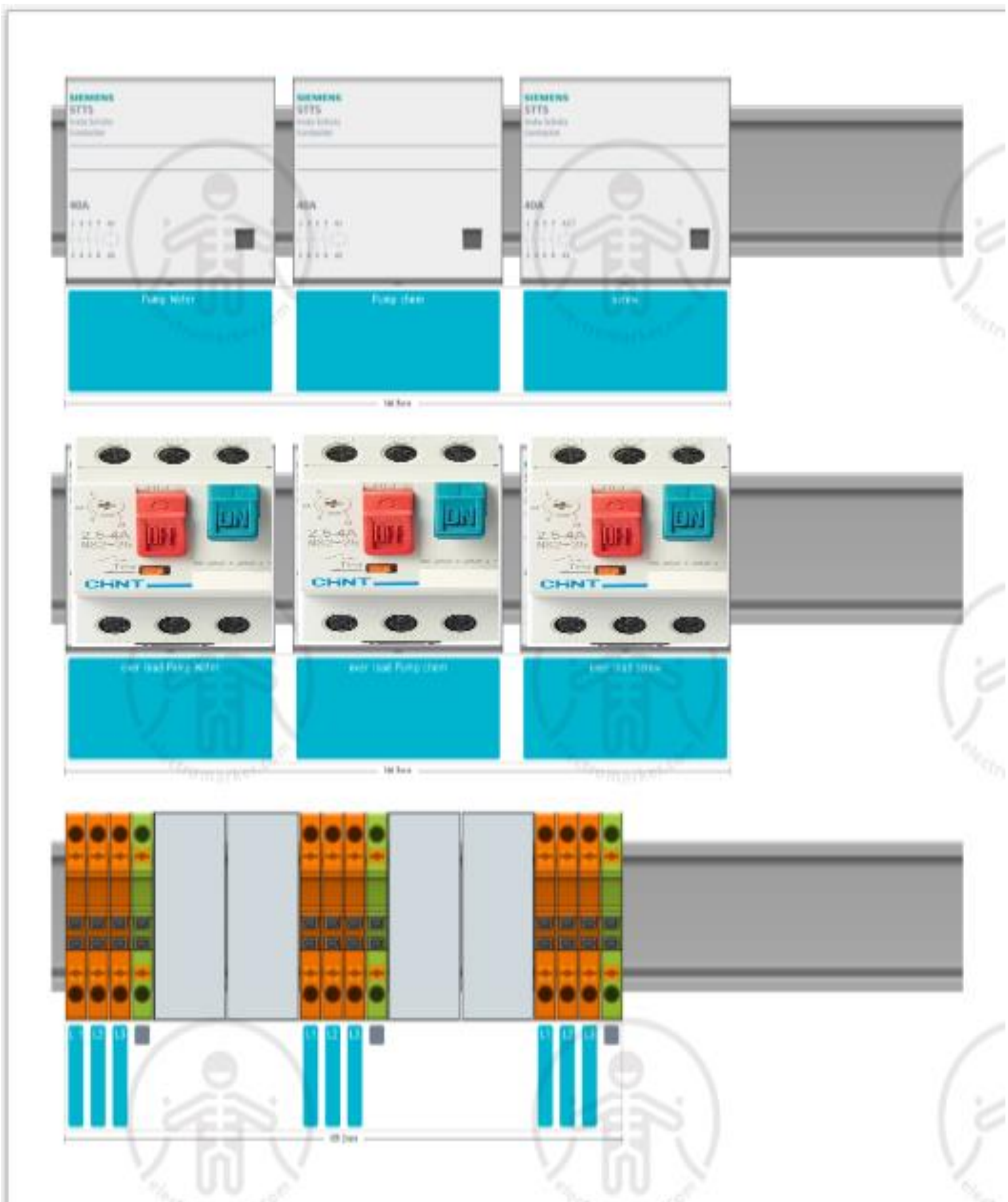


Figure 72:distribution board the pump (contactor and over load)

Chapter 4: Results and Analysis

In the first project, a SCADA system was implemented, using the DIAVIEW program. To enhance the user experience, I designed an intuitive and easy-to-use interface, including visual elements such as graphs and charts to improve data visualization and analysis. The interface prioritizes simplicity to reduce the learning curve for operators and supervisors, ensuring features are easy to access through clearly defined options. A responsive layout has been implemented to cater to different screen sizes and devices, promoting seamless cross-platform interaction. Through user testing and collecting feedback, the interface was refined to improve overall ease of use.

For monitoring and control purposes, you have enabled remote access to the concrete plant, and implemented strong security measures to protect sensitive data and prevent unauthorized access. In recognition of the local requirements and regulations in the Palestinian market, a comprehensive analysis was conducted which led to the system being customized to comply with local standards and compliance guidelines. Language support and cultural considerations are incorporated to facilitate smooth adoption by the local workforce.

The project also included implementing comprehensive data logging capabilities, recording key operational parameters over time. Generated detailed reports for performance analysis, maintenance planning and regulatory compliance. The design ensures easy retrieval of historical data for troubleshooting and decision-making purposes, enhancing the efficiency of the SCADA system.

In the second project, the PLC DVP 14 SS2 was chosen. It was programmed to experiment and create a control system that simulates the real system of a concrete plant without the use of additional modules, such as load modules and analog modules, due to their high cost. We will demonstrate how to select a PLC and show part of its programming using ISP Soft software. In this project, we carefully analyzed the control system requirements of a concrete plant and chose the DVP 14 SS2 PLC for its reliability and cost-effectiveness. Although no additional modules, such as load modules and analog modules, are used, we are determined to formulate a sophisticated control system using innovative programming techniques within ISP Soft software. Through careful planning and creative problem-solving, the team set about tackling the challenge of simulating a realistic factory environment to showcase the capabilities of the chosen PLC.

Chapter 5: Discussion

1. System Performance and Integration

The implementation of the Auto-Batch concrete control system has marked a significant milestone in automating concrete production processes. This system integrates several advanced technologies, including Programmable Logic Controllers (PLCs), Supervisory Control and Data Acquisition (SCADA) software. and the chosen Delta PLCs and DIAView SCADA software proved to be highly compatible, facilitating seamless communication and control across different components of the concrete plant.

2. Challenges Encountered

Throughout the development and deployment of the system, several challenges were encountered and addressed:

- Compatibility and Integration: Ensuring compatibility between the various hardware and software components was a critical challenge. The selection of Delta PLCs, which are known for their compatibility with DIAView SCADA software, helped mitigate this issue. Extensive testing was conducted to ensure all components worked harmoniously.

- Real-Time Data Processing: The need for real-time monitoring and data processing was paramount. The selected PLCs exhibited the necessary processing speed and I/O response time to meet these requirements, ensuring that the system could handle the dynamic demands of concrete production.

- User Interface Design: Creating an intuitive and user-friendly interface was essential for the effective operation of the system by plant operators and supervisors. The DIAView software provided a flexible platform for designing custom interfaces that facilitated easy monitoring and control while providing real-time data visualization.

Designing a system that simulates the real system of the ready-mixed concrete production line, using the system testing process, was effective, which led to testing all the features of Auto-Batch and contributed to giving promising first results for networking a realistic system in the near future.

This approach allowed the to identify potential areas for improvement and optimization, paving the way for a smoother integration process in the future. By meticulously testing each aspect of the Auto-Batch system, we were able to detect any bugs or issues early on, ensuring a more robust and reliable final product. This dedication to thorough testing not only guarantees a successful initial implementation but also sets the stage for future scalability and evolution of the system. As we move forward with networking the complete ready-mixed concrete production line, we can do so with confidence, knowing that our foundation is solid, and our path forward is clear.

The Auto-Batch concrete control system has successfully modernized the concrete production process, demonstrating significant improvements in efficiency, quality, and cost-effectiveness. The integration of advanced automation technologies has streamlined operations, reduced errors, and enhanced overall productivity. Moving forward, continued development and enhancements will further solidify the system's role in advancing the concrete industry, particularly in regions like Palestine, where infrastructure development is crucial for economic growth.

Chapter 6: Conclusions and Recommendation

6.1 Conclusions

The Graduation Project focused on addressing key challenges within the Palestinian ready-mixed concrete industry. The initial phase involved identifying issues such as inconsistent quality, lack of real-time monitoring, and inefficient processes. A comprehensive market analysis was conducted to understand the specific needs and requirements of the Palestinian market. Subsequently, market requirements and goals were defined, emphasizing the improvement of concrete quality to meet international standards and the implementation of a monitoring and control system to enhance factory performance.

By implementing the DIAVIEW program to design an advanced SCADA system specifically tailored to meet the unique requirements of Palestinian ready-mix concrete factories, the project aimed to take advantage of modern technologies to ensure real-time monitoring, control, and data acquisition. A comprehensive analysis was conducted on the factors affecting concrete quality, including raw material variations and production process parameters. Innovative solutions were developed to address these factors, ensuring a consistent, high-quality product.

The main objectives of the project included real-time monitoring of the entire concrete production process, precise control mechanisms for optimizing production parameters and enhancing quality, automation to minimize human error and improve efficiency, and the provision of a user-friendly interface for easy system operation and monitoring. Additionally, remote access and control were implemented for enhanced flexibility and management.

The overarching aim of the project was to provide maximum benefit to Palestinian ready-mixed concrete factories by ensuring consistent quality and operational efficiency. Future implications include the potential for increased competitiveness in the international market and contributing to local economic development through improved industry standards. In summary, the graduation project has yielded positive results by effectively addressing specific challenges in the Palestinian market and advancing the concrete production industry in Palestine through the implemented monitoring and control system designed with the DIAVIEW program.

Through study, analysis, and research aimed at designing an intelligent system to control a ready-mix concrete factory, we acquired knowledge about control systems. We explored their benefits, features, operation, and distinctions. For instance, we delved into the disparities between

PLC, DCS, and PID to understand their functionalities. We obtained experience in designing SCADA interfaces, identifying the different types of sensors used in factories, studying their mechanisms, and integrating them with PLCs. We've also cataloged most PLC manufacturers and their corresponding SCADA software.

While navigating the use of SCADA programs, we encountered challenges with options like Siemens Simatic SCADA (TIA Portal, WinCC) and Wonderware InTouch, primarily related to licensing issues. However, after an extensive search, we discovered the DIAVIEW program, affiliated with the Chinese company Delta. Remarkably, this program is free and operates continuously for two hours at a time.

This project focused on designing a control and automation system for a ready-mix concrete factory using the Delta DVP 14 SS2 PLC. The team analyzed the factory's requirements and developed a comprehensive control program with ISP Soft, achieving precise control over batching and mixing processes without the need for expensive load or analog modules. Innovative programming and accurate simulation enhanced operational efficiency and product quality while reducing costs. A user-friendly interface was created for monitoring and control, and rigorous testing ensured system reliability and stability. The project demonstrated that a cost-effective and reliable control system could be implemented, making it an ideal solution for similar industrial applications.

6.2 Recommendation

- Integration with Enterprise Resource Planning (ERP) Systems: Streamline production management by integrating the system with existing ERP software for holistic data analysis and resource planning.

- Advanced Process Optimization: Implement machine learning algorithms for real-time batching adjustments, predictive maintenance, and dynamic demand forecasting.

- Mobile Access and Remote Monitoring: Develop mobile app versions of the HMI for remote monitoring and control, enabling greater flexibility and responsiveness.

- Continued Research and Development: Explore integration with advanced technologies like digital twins, artificial intelligence, and robotics for further automation and optimization.

- One of the recommendations is to consider using the PLC DVP28sv2, as it is the suitable PLC to establish a practical automation and control system at the most optimal cost. Additionally, the PLC DVP28sv2 offers a user-friendly programming interface, reliable performance, and compatibility with various industrial communication protocols, making it a versatile choice for a wide range of automation applications. Its compact design and easy installation further contribute to its appeal as a cost-effective solution for enhancing control and efficiency in industrial settings.

6.3 future work

Future work will include developing the SCADA program and programming the PLC to fit the control system for ready-mixed concrete. This will be suitable for market students and customers, including the use of load cell units and the addition of an analog unit to enable networking of sensors such as Moisture Sensors and RFID Sensors. To obtain the appropriate PLC, the latest technologies in artificial intelligence and machine learning will be employed to optimize the control system efficiently. A user-friendly interface for SCADA will be designed for ease of operation and monitoring, providing multiple communication options with the control system, including access for different clients.

Additionally, the future system enhancements will focus on real-time data acquisition and analysis, which will help in predictive maintenance and reducing downtime. Integration with cloud services will allow for remote monitoring and control, ensuring that the plant can operate smoothly from anywhere in the world. The enhanced SCADA system will also support mobile device compatibility, offering flexibility and convenience for operators on the go. By leveraging these advanced technologies, the project aims to set a new standard in the automation of ready-mix concrete plants, combining efficiency, reliability, and user-friendliness in a comprehensive control solution.

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Appendices:

```
Sub ConditionScript_DataChangedOrTimeout()
        if Var.gate_sand1=True Then
          Var.VariableGroup0.Z1=True
          Var.VariableGroup0.G2=True
          Var.VariableGroup0.G1=False
           End if
        if Var.gate_sand1=False Then
          Var.VariableGroup0.Z1=False
          Var.VariableGroup0.G2=Falsea
          Var.VariableGroup0.G1=True
          End if
        if Var.gate_sand2=True Then
          Var.VariableGroup0.Z2=True
          Var.VariableGroup0.G4=True
          Var.VariableGroup0.G3=False
           End if
        if Var.gate_sand2=False Then
          Var.VariableGroup0.Z2=False
          Var.VariableGroup0.G3=True
          Var.VariableGroup0.G4=False
          End if
        if Var.gate_agg1=True Then
          Var.VariableGroup0.Z3=True
          Var.VariableGroup0.G5=False
          Var.VariableGroup0.G6=True
           End if
        if Var.gate_agg1=False Then
          Var.VariableGroup0.Z3=False
          Var.VariableGroup0.G5=True
          Var.VariableGroup0.G6=False
          End if
        if Var.gate_agg2=True Then
          Var.VariableGroup0.Z4=True
          Var.VariableGroup0.G7=False
          Var.VariableGroup0.G8=True
           End if
        if Var.gate_agg2=False Then
          Var.VariableGroup0.Z4=False
          Var.VariableGroup0.G7=True
          Var.VariableGroup0.G8=False
          End if
        if Var.gate_agg3=True Then
```

```
  Var.VariableGroup0.Z5=True
  Var.VariableGroup0.G9=False
  Var.VariableGroup0.G10=True
   End if
if Var.gate_agg3=False Then
  Var.VariableGroup0.Z5=False
  Var.VariableGroup0.G9=True
  Var.VariableGroup0.G10=False
  End if
  If Var.out_gate_mixer=True Then
   Var.VariableGroup0.Z16=True
   Var.VariableGroup0.G23=False
   Var.VariableGroup0.G24=False
   Var.VariableGroup0.G25=True
   Var.VariableGroup0.G26=True
   End if
  If Var.out_gate_mixer=False Then
   Var.VariableGroup0.Z16=False
   Var.VariableGroup0.G23=True
   Var.VariableGroup0.G24=True
   Var.VariableGroup0.G25=False
   Var.VariableGroup0.G26=False
   End if
   If Var.gate_cem1_1=True Then
   Var.VariableGroup0.Z6=True
   Var.VariableGroup0.G11=False
   Var.VariableGroup0.G12=False
   Var.VariableGroup0.G13=True
   Var.VariableGroup0.G14=True
   End if
  If Var.gate_cem1_1=False Then
   Var.VariableGroup0.Z6=False
   Var.VariableGroup0.G11=True
   Var.VariableGroup0.G12=True
   Var.VariableGroup0.G13=False
   Var.VariableGroup0.G14=False
   End if
   If Var.out_gate_chem=True Then
   Var.VariableGroup0.Z7=True
   Var.VariableGroup0.G15=False
   Var.VariableGroup0.G16=False
   Var.VariableGroup0.G17=True
   Var.VariableGroup0.G18=True
```

```
End if
If Var.out_gate_chem=False Then
 Var.VariableGroup0.Z7=False
 Var.VariableGroup0.G15=True
 Var.VariableGroup0.G16=True
 Var.VariableGroup0.G17=False
 Var.VariableGroup0.G18=False
 End if
 If Var.out_gate_weight_water=True Then
 Var.VariableGroup0.Z8=True
 Var.VariableGroup0.G19=False
 Var.VariableGroup0.G20=False
 Var.VariableGroup0.G21=True
 Var.VariableGroup0.G22=True
 End if
If Var.out_gate_weight_water=False Then
 Var.VariableGroup0.Z8=False
 Var.VariableGroup0.G19=True
 Var.VariableGroup0.G20=True
 Var.VariableGroup0.G21=False
 Var.VariableGroup0.G22=False
 End if
If Var.pump_chem=True Then
 Var.VariableGroup0.Z11=True
End if
 If Var.pump_chem=False Then
 Var.VariableGroup0.Z11=False
End if
 If Var.pump_water=True Then
 Var.VariableGroup0.Z12=True
End if
 If Var.pump_water=False Then
 Var.VariableGroup0.Z12=False
 End if
If Var.out_scerw_cem1=True Then
 Var.VariableGroup0.Z9=True
 Var.VariableGroup0.Z10=True
End if
 If Var.out_scerw_cem1=False Then
 Var.VariableGroup0.Z9=False
 Var.VariableGroup0.Z10=False
End if
If Var.manual_mode=True Then
```

```
        Var.VariableGroup0.MN=True
      end If
      If Var.manual_mode=False Then
        Var.VariableGroup0.MN=False
      end If
      If Var.auto_mode=True Then
        Var.VariableGroup0.AT=True
      end If
      If Var.auto_mode=False Then
        Var.VariableGroup0.AT=False
      end If
     If Var.sensor_gate_close=True Then
       Var.VariableGroup0.CG=True
      end If
     If Var.sensor_gate_close=False Then
       Var.VariableGroup0.CG=False
      End If
     If Var.sensor_gate_open=True Then
       Var.VariableGroup0.OG=True
      End If
      If Var.sensor_gate_open=False Then
       Var.VariableGroup0.OG=False
      End If
      If Var.finsh_Order=True Then
       Var.VariableGroup0.FO=True
      End If
      If Var.finsh_Order=False Then
       Var.VariableGroup0.FO=False
      End If

End Sub
```